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Technical Surveys

Mr. J. G. Pearce, the director of the British Cast Iron Research Association, has done a really useful service to the iron-foundry industry by detailing to the town's gas interests just exactly how, where and why cast iron enters into their production and distribution problems. It should be realised that the gas industry is relatively much more important in this country than in any other of the great industrial countries. Whilst Germany is actually much more important from the point of view of the production of electricity, it does not generate anything like the quantity of town's gas as does Great Britain. A similar service has recently been given by Dr. Everest, who disclosed to the chemical engineers the field of application for the newer cast irons. Only a few engineering technological societies, however, lend themselves to such treatment, because many of them cater for industries which have foundries attached to them as manufacturing departments. These naturally rely on their managers and foremen to keep them posted as to the application of the best material for the various types of components used.

The suggestion obviously arises that these managers should themselves make a similar logical survey of the ramifications of the industry they serve, with the object of ascertaining that they are supplying the best material available consistent with prevailing price levels, and the manufacturing facilities available to them. It must not be imagined that because a mixture has served them in good stead for perhaps a couple of decades, that it is the best possible, and, moreover, even if it be, a reason should be sought for its excellence. Designs cannot be relied upon to be static and a change may introduce troubles not solvable by the use of the established mix. A study of this kind involves a certain amount of detached thought, and instead of regarding a mix as 5 cwts. of Jones' No. 3, 5 cwts. of Smith's special and 10 cwts. of back scrap, an effort should be made to visualise just what sort of iron has been produced. Is it all-pearlitic?—is the graphite finely divided or coarse? and so forth. The modern foundry executive no longer regards sand as would a lay man, but looks on it as, maybe, grains of silica bonded with clay. Yet an insufficient number have so far divorced themselves from the mechanical make-up of the charges to correlate their products with the microstructure. This phase of assessment is much more important in grey iron-foundry practice than in steel making, for in the latter case, a reference to the carbon content suffices. After that it is a question of alloying or heat-treatment to get the requisite properties, but until the "special steel" range is reached, carbon content is always the major consideration. A survey such as we have indicated, when applied to, say, marine engineering, will disclose a series of irons just as wide as that required for gas making and distributing. Non-growth irons for the boiler grates; erosion and corrosion-resisting irons for the propellers; special irons for the cylinders, valves, and so forth. Since it has been possible to replace manganese steel by special white cast iron for various crushing jobs, it might be worth while taking into consideration the possibility of making dredger buckets from such material.

To apply this "survey" system to mining, textile engineering, agricultural implements, building materials, domestic appliances, power plants, and all the vast array of industries for which foundry caters, would give an assurance that all sections of engineering were aware of the latest and best foundry productions, and that the foundry making the survey was or was not in a position to supply their needs.

When the sales manager of a foundry receives for the first time an order from, say, the cement industry for a special component, he immediately makes a survey of this trade and instructs all the travellers to call on the firms situated within their areas. Thus it is only logical that when a foundry executive makes castings for an industry, he should familiarise himself with the technical needs of that industry and correlate with those needs the grades of iron he makes. If amongst these grades there are no irons capable of meeting the conditions encountered, then his list should be extended to embrace them, or a decision taken that such a venture is not worth while. Actually the cast iron foundry industry is at the cross roads, and many are anxious to find out whether the future will see a grouping into those specialising in high-duty irons and those confining their activities to plain material.

Already a number of concerns have achieved a reputation for high-duty irons, many more do a mixed business, whilst still others, such as the majority of the light castings trade, find no reason for departing from the traditional specifications. It is to the second class that our remarks apply, but we feel that existing conditions will continue, and there will never be in the foundry industry a condition similar to that existing in the steel trade, where there are dozens of small works specialising in the production of high-class tool steel and the like, whilst where the largest firms conduct such a business, it is carried out in a special department.

Dearer Lead?

By "ONLOOKER."

The projected lead cartel has been hailed as likely to enable the producers to market their output at a level approaching £20, but at the time of writing optimistic buying on the London market, mainly by speculators, has only proved instrumental in lifting values £1 or so to £15 10s., which is some way below the best seen this year. In March, both spot and forward lead climbed over £17, but this was followed by a sharp fall, and during May and June, when the copper market suffered a collapse, lead went down to £13 5s. for the spot position. Not unnaturally this proved attractive to buyers, and as a result of their participation and the better trend on the American stock markets an advance took place. Nevertheless, things have not looked too good with this metal and on two or three occasions since it has seemed as if the price would break £14. Evidently the lead producers have not been feeling too happy about the situation and the present step has been taken in an attempt to put things right, although those people who believe that a commodity should be left to work out its own salvation will not be over pleased at the proposal to introduce a scheme of artificial control.

Looking back to last year it is, of course, not unnatural that the lead interests should feel rather sorry for themselves since the lowest point touched was £15 10s. and the highest £36 7s. 6d.! The latter figure must, of course, be regarded as exceptional, although it was equalled and even surpassed during the war and in the two following years, when as a matter of fact a record high level was set up with £53 7s. 6d. in 1920. Lead has also suffered its bad patches in values, the period 1931 to 1934 being one of the worst, for the best level achieved was only £15 12s. 6d. while 1932 saw the quotation down to £9 3s. 9d. This was very near the lowest ever recorded for lead, but we have to go back to 1894 to find £9 per ton which is what the Americans would call an all time low. Perhaps in their approach to a cartel the producers have in mind the possibility of a return to such starvation levels, and if so one certainly cannot blame them for making some endeavour to keep the price at a reasonable figure. It is over that, however, that the opponents of a curtailment policy join issue, for they suggest that the opportunity will be seized to push the price up against the consumer. It is understood, however, that the plans for this lead restriction scheme are on very much the same lines as in copper, and, if this be so, then things ought not to be too bad, for it must be admitted that the copper people have set their faces against an inflated price.

Consumption of lead, although lower in this country than it was last year, is maintained at quite a good level, but it would probably be right to say that a 25 per cent. advance in the quotation would almost certainly operate to reduce consumption, for in these days there is keen competition from other metals whenever the opportunity arises. As far as duties are concerned, lead is in rather a fortunate position, for whereas spelter which stands about 30s. lower in price is subject to an impost of 12s. 6d., lead is rated at only 7s. 6d. The Empire brands are allowed to command a premium of 7s. 6d., and it can be said that both foreign and Empire metal circulate quite freely, but, of course, there is little else but foreign metal found in the bonded warehouses. As mentioned above, buying, since news of curtailment came in, has been mainly speculative, and the probability is that consumers are holding good reserves, for it cannot be doubted that the details of stocks in official warehouses do not by any means complete the picture for this country. Provided the curtailment plan goes through a rather higher price ought to rule, but a runaway market is unlikely.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

"Tropenas" Practice

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Mr. Harry A. Baird does not need anyone to support him, but in view of the points raised in your issue of September 1 by Mr. H. Taylor, I would like to put forward the following:—

(1) The scrap used could easily be lower in sulphur than the pig-iron. Provided the scrap was not too thick or too large, it would melt quickly; therefore the pick-up of sulphur from the coke would be lower than usual. Mr. Baird's figure of 0.03 per cent. seems to prove this.

(2) It surely does not follow that because steel is blown for less than 15 min. it cannot be good and clean? Once the blow is finished (and before the additions are made) the metal is in the same condition for each heat, with the exception of the temperature; and provided the various heats are finished in about the same time (not sooner or later), surely the finished steel will be very approximately the same?

(3) The more the metal is blown, the more difficult it is to kill. Over-blown metal can never be killed.

Perhaps some expert will be good enough to correct me on any of the points, if such correction be necessary.—Yours, etc.,

T. MCLEAN
(Managing Director, Parker Foundry (1929), Limited).

Derby. September 9, 1938.

A Useful Foundry Tool

All foundrymen are familiar with the delays often encountered when broken corners of cores have to be mended and dried, or when the loam used to stop-in around the cores in a dry-sand job has to be dried subsequent to the final lowering of the top moulding box.

On such occasions it is still customary in many shops to resort to the use of a hot bar for this drying. This method whilst being often dirty, is also unsound from a drying point of view.

A patched core or a stopped-in mould should be dried gradually at first and then more rapidly, a hot bar acts, however, in an opposite manner, the job being at first dried fiercely and then more slowly. An advance on this method is to use a paraffin blowlamp in which the flame can be regulated to suit the conditions required.

Still greater efficiency can be obtained, however, from the use of an apparatus now on the market in which a liquid fuel is gasified and used in a special burner. This burner is designed to supersede the use of a blowlamp and the apparatus in question has many distinct advantages over the older system. The liquid fuel is contained in bottles which hold about 200 cub. ft. of fuel. These containers are about 1 ft. dia. and 2 ft. deep and weigh just over half a hundredweight. The fuel gasifies without heat and is delivered from the container to the burner through a rubber tube.

A central position in the shop could be conveniently used to store the fuel container and a length of tube with the burner fixed at one end could be attached to this and used over a very wide area as required, similar to air and water hoses, etc. All that is required to operate this apparatus is to turn on the gas and apply a light to the burner. One valve controls the flame intensity, while another ensures safety.

The advantages shown by the apparatus are:—Constant refuelling is unnecessary, thus minimising fear of explosions as sometimes occur with blowlamps. The burner requires no priming and is thus ready for immediate use, while the flame can be regulated from high to low.

Random Shots

From time to time one hears quiet questionings over the choice of a rendezvous for conferences. Other societies can hold their yearly meetings at Blackpool, Southport and Bournemouth; why not the foundry industry also? "Marksman" would like to suggest that if the foundrymen should at any time decide to go "all-sea-sidey," they should support Brighton. Blackpool is a town of ferro-concrete, but Brighton is a cast-iron paradise, whose promenade and garden railings must have consumed thousands and thousands of tons of cast iron. A walk along the front the other day revealed the fact that there are at least a thousand sections along one part of the parade alone. If each section weighs about 1 cwt., it does not need a night-school course in mathematics to calculate approximately to what extent Brighton has supported the foundry industry. Is not such staunch support worthy of recognition?

* * *

Talking of night schools reminds one that the winter sessions are about to begin again. Evening classes in London are part of a very highly organised system of adult education, which has been developed to the last degree. "Marksman" knows of one School of Modern Languages run by the L.C.C. which is taken so seriously that its students turn up to the Russian class in fur coats (concealing, no doubt, ties of vivid red), and invariably precede a German lesson with a hasty meal of Frankfurter sausages and Sauerkraut. The provinces, however, are equally alert to the needs of their citizens, and one hears that Chesterfield, for instance, is starting a new course in foundrywork in its evening class system.

* * *

On the whole, they are a cheery lot of lads who attend these classes. One youth whistled his way down the street, up the stairs, and did not trouble to stop in the classroom. The lecturer arrived, but the glad youth went on with his blithe song. At last the nerves of the lecturer became a trifle frayed, and with that sarcasm which drops so easily from pedagogic lips he remarked, "Well, my lad, don't you think you'd better begin again. We haven't heard your signature tune yet!"

* * *

There was a directors' meeting. There had been a woman auditor and the books were chaotic. General confusion had caused quite a hubbub of heated discussion. Then came one of those awkward pauses which invariably occur at either twenty minutes to or twenty minutes past the hour, when someone caught sight of a host of footnotes, referred to by an abundance of daggers, double daggers and asterisks. "I say, Smith," he boomed out into the vast emptiness of a moment's silence, "Is this one a through train or a restaurant car?"

* * *

The main road leading out of the seaside town had a large field of cabbages flanking the roadside. In it was a notice, "For Sale. Excellent building plots." One could not help thinking "Cabbages to-day. Mushrooms to-morrow?"

* * *

It was the King's birthday. A suitable number of guns had been fired in his honour. The next day there happened to be a thunderstorm and from a cheerful little Cockney came the remark, "Blimey! 'oos blinking birfday is it to-dy?"

"MARKSMAN."

Shrinkage and Contraction of Cast Iron*

By A. A. TIMMINS, A.I.C., A.C.T.C.

The problem of shrinkage is one which concerns all foundrymen for it is present in every casting that is made. In some cases its effects are not noticeable, but in others it manifests itself in the formation of porous areas or cracked and warped castings.

Much has been done by both foundrymen and metallurgists to eliminate this trouble, but despite their efforts, successful as they are in some cases, the problem of shrinkage is still a vital one in the foundry.

From a steel or non-ferrous foundrymen's point of view the founding of cast iron is relatively

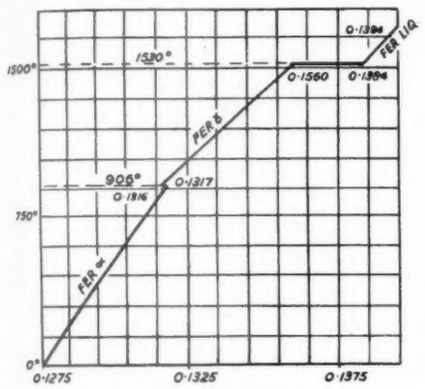


FIG. 1.—VOLUME CHANGES IN PURE IRON.

easy, and whilst this is certainly true, it must be remembered that cast iron is far from being a pure material, and at certain stages in its cooling it may contain a number of components, each of which exhibits its own shrinkage characteristics. After solidification, further constitutional changes may occur with alteration in the solid contraction. In addition, with grey cast iron, there is the phenomena of graphitisation and the accompanying expansion.

There is possibly no need to remind foundrymen of the troubles met with in castings due to shrinkage, but, generally speaking, they may be classified into three main types. First, there

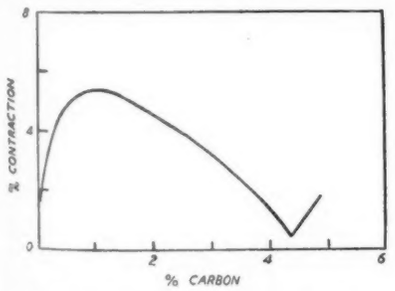


FIG. 2.—EFFECT OF CARBON ON THE SOLIDIFICATION SHRINKAGE OF PURE IRON.

is the common draw which occurs as a jagged cavity in the centre of heavy sections or near a change of section. Secondly, there is the sink which occurs as a depression on the top of thick sections—a variation being a closed or open pipe or a hot tear. Finally, there is the cracked and warping met with in light castings.

These defects are due to such factors as:—(1) Composition, (2) temperature of pouring, (3) moulding conditions, running, etc., and (4) type of casting.

* A Paper read before the Birmingham Branch of the Institute of British Foundrymen.

Fundamentally, the effects are due to the volume changes which take place when cast iron cools from the liquid condition to room temperature. Cast iron, in common with other metals, shows three distinct volume changes:—(1) During the liquid state or "liquid shrinkage," (2) during solidification or "solidification shrinkage," and (3) during the solid state or "solid shrinkage."

Case of Pure Metals

With pure metals there is simply a decrease in volume in the liquid state, a serious decrease during solidification and a smaller decrease in volume in the solid state (see Fig. 1). With cast iron, however, the problem is more complex, as an expansion may occur on solidification if the iron is grey or a contraction if the iron is white. There are also changes occurring in the solid state, which modify the contraction.

Liquid Shrinkage

It seems generally agreed that liquid cast iron undergoes a decrease in volume in direct proportion to the fall in temperature. This means that the higher the temperature of the liquid metal, the greater will be the change in volume before it commences to solidify. Composition does not materially alter the volume change, for whilst an increase in phosphorus, silicon or carbon increases the volume at a given temperature, the actual change in volume which occurs for a given temperature fall remains the same.

Solidification Shrinkage

This is the volume change which occurs when the liquid metal changes to the solid state, and is governed mainly by two factors:—(1) The carbon content; and (2) the condition of the carbon, whether it is free as graphite, as in a grey iron, or combined as cementite as in white iron. White irons all show a decrease in volume on solidification, but by measuring the volume changes with small quantities of metal, it has been shown that this decrease is a maximum at 1 per cent. carbon and a minimum at 4.3 per cent., namely, the eutectic composition, as shown in Fig. 2.

In grey iron there is also a contraction in volume when the carbon content is low, but as the amount of carbon is increased, the contraction decreases, and is eventually offset by an expansion when carbon reaches eutectic composition.

This is due to the fact that the formation of graphite during solidification causes an increase in volume which will naturally get bigger as the carbon content, and therefore the amount of graphite, increases. Fig. 3 shows the effect of graphite content of cast iron as determined by Honda and Endo. From this point of view, therefore, high carbon irons show the least shrinkage. It should be realised that such results were obtained on small amounts of metal, and do not take into account such factors as section and temperature gradient. Such tests, therefore, indicate the intrinsic shrinkage, but not its distribution in a casting.

Solid Contraction

After solidification, cast iron still continues to contract with fall in temperature, but the actual behaviour depends on composition and the rate of cooling of the iron. Whereas a pure metal contracts uniformly with fall in temperature, the contraction of cast iron is modified by certain changes. White irons contract in a similar manner to pure metals, except that at about 700 deg. C. an expansion occurs due to the change of austenite to pearlite. Low phosphoric grey irons contract to a lesser degree, due to the fact that some graphite is precipitated during cooling in the solid state, and is accompanied by an expansion which tends to offset the normal contraction.

The amount of solid contraction in a grey iron, therefore, will be largely governed by the carbon remaining in solution, and any factor, such as an addition of silicon, or slower rate of cooling, favours the formation of graphite, and will tend to decrease solid contraction. Conversely, the addition of carbide stabilisers or faster rate of cooling will increase the contraction by retaining more carbon in the combined form. High-phosphorous irons contain large quantities of phosphide eutectic which remain liquid after the main part of the iron has solidified, and on solidifying at 950 deg. C. give an expansion. Turner has measured the contraction of irons of various compositions by allowing the molten iron to solidify round a small bar attached to a needle moving over a graduated scale. As the iron contracts, the needle moves over the scale

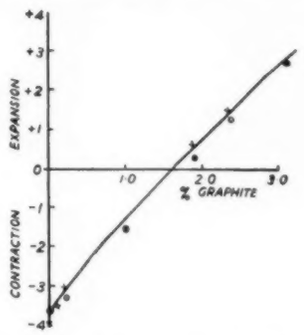


FIG. 3.—EFFECT OF GRAPHITE ON THE VOLUME CHANGE AT SOLIDIFICATION. (HONDA AND ENDO.)

and registers the contraction. Turner's results are shown in Fig. 4.

From a theoretical aspect, therefore, one would expect white irons to show greater shrinkage than grey irons, and every foundrymen knows that white irons present greater difficulties in casting than grey irons. It would also appear that shrinkage of white irons depends on the carbon content being reduced considerably, and one might expect greater difficulty with low-carbon irons than high-carbon irons. This is clearly borne out in Fig. 5, which depicts the

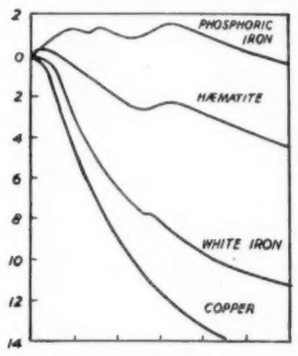


FIG. 4.—TURNER'S CONTRACTION CURVES.

fracture of two white iron bars, 2 in. diameter, containing 2 and 3.5 per cent. C respectively. The 2 per cent. carbon is actually porous throughout its length.

Applying the same principle to grey irons, it is reasonable to expect that the best method of overcoming shrinkage would be to employ an iron with high-carbon content in order to ensure soundness and also to arrange for as much graphite as possible to be precipitated during solidification, on the assumption that by so doing it is possible to offset solidification to the maxi-

mum extent. Whilst this is true for small quantities of metal which freeze relatively quickly, it does not apply to heavy castings, as there are such effects as rate of cooling, method of running and the like to be considered. It is the effect of these variables on the volume changes and the method of solidification which determines to a large extent the success or otherwise of the casting process.

Influence of Composition

Considerable work has been conducted by foundrymen and metallurgists with a view to determining the effects of composition on shrinkage, but the outstanding and conclusive work in this direction was conducted by the

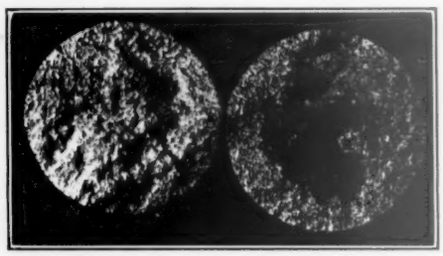


FIG. 5.—EFFECT OF CARBON ON POROSITY IN WHITE IRON BARS.

Grey Iron Sub-Committee of the Institute's Technical Committee.

This committee was concerned with the influence of carbon and phosphorus and devised a test of cruciform type, but also used a cylinder block for their investigations. The results of the work showed that carbon and phosphorus were vital factors concerning shrinkage and are interrelated in their effects.

The effect of total carbon and phosphorus on an iron containing 2 per cent. silicon in the high-carbon series porosity was shown to appear at a phosphorus content of 0.3 per cent. and then increased in amount as the phosphorus was raised. With the lower carbon content (2.6 per cent. C) porosity did not appear until about 0.75 per cent. phosphorus was reached. Thus, as the phosphorus content is raised the carbon content must be progressively decreased in order to achieve freedom from porosity. It also in-

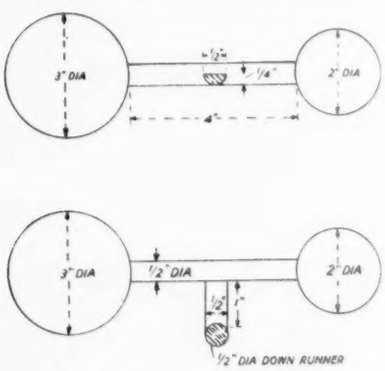


FIG. 6.—DUMB-BELL TEST-PIECE.

volves that when the phosphorus is low, the carbon content can be varied over a much wider range without causing unsoundness.

Tests carried out by the B.C.I.R.A. substantially confirm these results, but further show that the unsoundness is governed by silicon content.

A Dumb-bell Test-Piece

In its investigations, the Association employed a dumb-bell form of test-piece (as shown in Fig. 6), devised with object of reducing the number of conflicting factors and yet enabling a study to be made of the cooling of a fair quantity of metal. Under these conditions shrinkage was exaggerated and all irons showed shrinkage, but both types varied with composition. Fig. 7 shows the effect of silicon on irons containing 1 per cent. phosphorus and varying total carbon content. With the high carbon series, porosity is absent when the silicon is low, but gradually increases as the amount of this element is raised and becomes very marked at 2 per cent. silicon. In the low carbon series, however, porosity is absent at all silicon contents, but the tendency for sinking is greater.

Thus both silicon and phosphorus increase porosity when the total carbon is high and with lower carbon irons, silicon and phosphorus can be high and silicon varied over a wide range without causing unsoundness. This fact can, and often is, made use of in cases where light and complicated castings have to be made from the same metal. Fluidity is not impaired and soundness obtained in the heavy sections whilst machinability is achieved with the lighter castings.

How can the previous theory be modified to explain these facts? It is suggested that the porosity present in high carbon irons is to a large extent due to the openness caused by coarse graphite flakes.

Theoretical Considerations

Theoretically, minimum shrinkage is obtained in a grey iron when the iron is of eutectic composition with respect to carbon and is due to the eutectic carbon being precipitated during solidification and causing an expansion. Now silicon and phosphorus lower the amount of carbon required for the eutectic composition by amount equal to 0.3 per cent. for every 1 per cent. of silicon or phosphorus. Fig. 8 shows the effect of silicon and phosphorus on the carbon content of the eutectic.

When a large mass of high carbon iron containing high silicon or phosphorus cools down a certain amount of graphite will be precipitated before the iron solidifies, and, having greater facility for growth, will be present as coarse flakes imparting openness to the iron. As the iron is still liquid, these constituents cannot cause any useful expansion. When the iron freezes, there is less carbon available for expansion due to the effect of silicon and the iron is porous. With decrease in carbon content, the graphite becomes smaller and there is less chance for porosity to appear. At the same time, however, the intrinsic shrinkage increases and there is greater tendency for piping.

The same arguments apply to phosphorus, but in addition there is its influence on the nature of the cooling. Phosphorus is present in cast iron as a eutectic which does not solidify until 950 deg. C., that is, some 200 deg. C. after the rest of the iron is solid. Thus, when the iron has solidified, there are still areas containing liquid phosphide eutectic which contract on further cooling, leaving voids which cannot be filled by the expansion resulting from the freezing of the phosphide eutectic at 950 deg. C. It is also essential to bear in mind the method of cooling of the metal in the mould. In heavy sections there is a temperature gradient in the casting which causes the metal to freeze from the outside towards the middle. This cooling also takes place faster at the bottom owing to the tendency for the hotter metal to rise to the top. The final metal to solidify will be just above the middle of the casting, but the actual position will depend on temperature gradient.

With high carbon irons during cooling, free graphite will be precipitated in a coarser form, and when the eutectic solidifies, it does so relatively sharply, and the supply of liquid metal which may make up any shrinkage cavity is more easily cut off and may result in porosity. This effect is greatly increased in high-silicon—high-phosphorus irons, owing to the smaller amount of carbon in the eutectic, and hence less carbon available for expansion. Irons below the eutectic composition have a freezing range (during which liquid is in contact with solid metal), involving a smaller temperature gradient and more chance for metal to feed from runner or riser, and so reducing the tendency to form voids, even though the intrinsic shrinkage of the iron be higher. The result is not porosity, but sinking or piping.

Shrinkage in a mass of mteal is related to composition, silicon, carbon and phosphorus being the outstanding elements concerned. Low phosphorus, low silicon irons are least prone to shrinkage troubles, but as silicon or phosphorus is raised, there is an increasing tendency towards porosity appearing in heavy sections. This porosity can be avoided by decrease in total carbon in proportion to the increase in silicon or

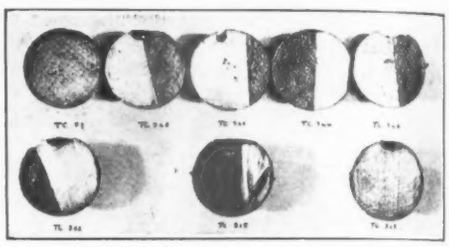


FIG. 7.—EFFECT OF SI + T.C ON POROSITY.

phosphorus, but it must be realised that, though these low total carbon irons are sound, they have a greater intrinsic shrinkage which may need greater care in running methods to ensure freedom from sinking or piping.

Influence of Section Thickness

Besides being affected by composition, shrinkage is profoundly influenced by the section of the casting. With moderately small sections, very little difficulty is experienced, but with larger sections, the effect of composition becomes more noticeable, and with high carbon irons it is necessary to use low silicon and phosphorus in order to avoid porous areas. If it is essential to use high silicon or phosphorus on account of machinability or fluidity, the carbon content must be decreased.

When the section is very large, or if the change of section be such that a heavy section is cut off from liquid metal by premature solidification of

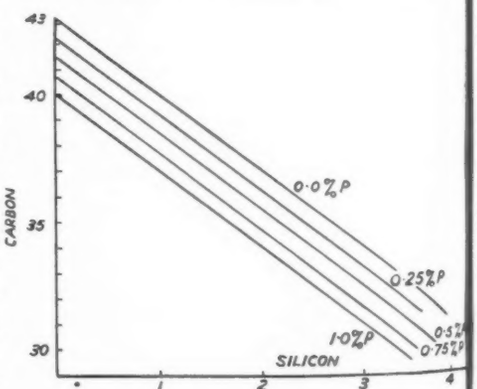


FIG. 8.—EFFECT OF SILICON AND PHOSPHORUS ON THE CARBON IN THE EUTECTIC.

the adjoining thin portions, then both high and low carbon irons will result in unsound castings, particularly if high in silicon and phosphorus. Whereas high carbon irons will give centre porosity unseen from the outside, the low carbon iron will probably result in severe piping.

High carbon, low silicon and low phosphorus irons will be perfectly sound, but the high carbon, high silicon, high phosphorus will result in porosity in the centre of the heavy section. A combination of low carbon, high silicon and high phosphorus will result in sinking or piping, which

could only be avoided by the use of risers, shrink bobs or rod feeding. This is illustrated in Fig. 9.

The question of running and foundry technique plays a serious part in the production of sound castings, and, given the correct iron, the running of the casting will make or mar the job. The primary object is to fill the mould and then arrange as far as possible the cooling of the casting in such a manner that solidification is directional, *i.e.*, taking place gradually from the thicker portions towards the runner or riser.

It is obvious that if a heavy section be cut off while still partially molten by the design prior to the solidification of an adjoining section, there will be little chance of feeding and the cooling condition will approximate to that of the dumb-bell. For this reason foundrymen find in most cases that it is desirable to run a casting

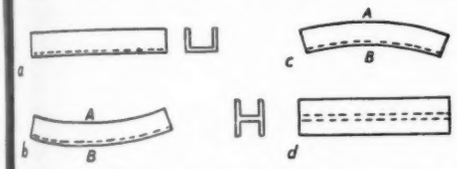


FIG. 9.—WARPING IN CASTINGS OF CHANNEL SECTION.

through the thin parts into the thick ones, so tending to even up the temperature gradient and increase the chances of feeding. If the gradient is too large to be reduced in this way, resort must be made to risers or shrink bobs. Chills are also used for similar reasons, but they must be applied judiciously and not with the idea of cooling the casting quickly so much as promoting more directional cooling from chill to riser or runner.

Effect of Pouring Temperature

The effect of pouring temperature on soundness of castings has been the subject of controversy for a number of years. Several writers, notably Buchanan and Smalley, hold the view that the hotter the metal the sounder will be the casting, whilst Dews and others are of the opinion that high casting temperatures are serious, as they tend to give greater liquid contraction. Hailstone concluded that there was a definite minimum casting temperature for every iron for the production of sound castings. There seems little doubt that there is a minimum pouring temperature, for cold metal, apart from its effect on shrinkage, causes other defects, such as lack of fluidity, blow-holes, and cold shuts. It is a personal belief that pouring temperature is bound up with the question of section, and pouring temperature must be considered in relation to the casting itself.

A high pouring temperature certainly means a greater liquid shrinkage before solidification, but theoretically this would not have any effect until portions of the casting commenced to solidify, as the liquid casting would simply contract and draw further liquid from the runner or riser. If, however, the temperature gradients are such that the passage between runner and thick section are prematurely cut off, while there is still liquid metal at high temperature in the centre of the thick section, then shrinkage will be increased, for besides that due to solidification shrinkage, there will also be the contraction of the liquid metal.

Apart from this exception, hot metal tends to lower the temperature gradient by warming the mould and hence allowing more feeding. These ideas are borne out in tests made on the dumb-bell test-piece and they show that with sound irons sinking is reduced by fall in pouring temperature. On the other hand, porous irons appear sounder when at high temperatures. Too much reliance, however, should not be placed on these results, and much will depend on the rates of cooling of the various parts of the casting.

Contraction and its Relation to Warping and Cracking

The phenomenon of warping and cracking are as well known to the founder as is the problem of shrinkage. The products of light castings industry are particularly prone to these defects, but such castings as spoked pulley wheels, bed plates, etc., also suffer from its effects. The problem is fundamentally one of design, that is, a change in section producing an uneven cooling rate in different parts of the casting impeding the natural contraction of the metal. A single example of this uneven cooling rate is seen in the case of guttered shaped castings. (Fig. 9.) The edges A cool more rapidly than the portion B, and in contracting they tend to compress the thicker portions. Owing to the resistance of B, the portion A cannot contract to its fullest extent, and the casting takes a camber with the thicker portions on the outside. Meanwhile the thick portions are exerting their contraction, and do so to normal length, thereby pulling on A and causing the camber to operate in the opposite direction. There is thus a tension on A and a compression on B. Warping and cracking are therefore due to the hindering of the contraction of one part of the casting by another, a condition brought about by irregular cooling. With the majority of castings the problem is confined to contraction in the solid state and briefly may be said to be influenced by the following points:—(1) Variation in rate of cooling; (2) composition, and (3) strength at high temperatures.

The variation in rate of cooling is by far the most important point, as this factor will determine to a large extent the amount of contraction and the temperature at which the resulting stress is applied to any particular section. For a given set of conditions the tendency to warp or crack increases with variation in section, and therefore with difference in cooling rate. Again, for any variation in cooling rate, the tendency to warp or crack will vary with the solid contraction, the value of which depends on composition and ultimately on the amount of combined carbon.

Increase in silicon and carbon will decrease it by tending to reduce the amount of combined

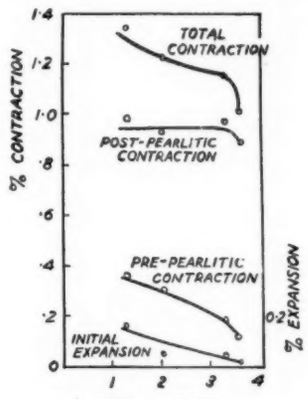


FIG. 10.—EFFECT OF SILICON ON SOLID CONTRACTION.

carbon. The effect of silicon and carbon is confined to that period of the contraction from solidification down to the pearlite point at 700 deg. C., and is due to the further precipitation of graphite in the solid state entering an expansion. Retention of graphite will naturally increase contraction. Contraction below 700 deg. C. is not affected by composition. Rate of cooling also affects contraction, slow cooling favouring precipitation of graphite. Figs. 10 and 11 show respectively the effect of silicon and mould temperature (*i.e.*, rate of cooling) on the solid contraction. The tendency to warp or crack is also dependent on the strength of the section at which the stress is applied. If the section is too weak it will crack, whilst if a little stronger and plastic, it may warp. With still stronger sections, the castings may neither warp nor crack, but remain in a state of stress, a fact made very evident in subsequent machining.

This reasoning applies only to the strength of the section at the particular temperature of stress application, and is therefore governed by variation in rate of cooling. If the stress is applied at high temperatures, the effect of composition on the strength will be nil, as all irons

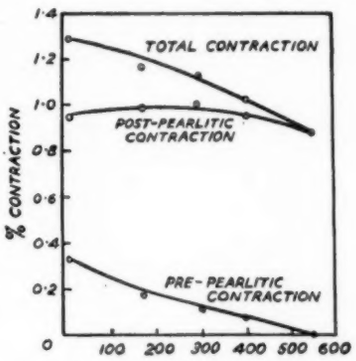


FIG. 11.—EFFECT OF MOULD TEMPERATURE ON SOLID CONTRACTION.

tend then to have the same low strength. At lower temperatures, greater differences will occur between various irons and the strongest may be stiff enough at that temperature to resist the stress. It will thus be apparent that variation in rate of cooling is the major factor, composition and strength being incidental to it.

In some cases warping is avoided by previous cambering of the pattern or by bedding in when moulding. A great deal can also be done by altering the position of runners, etc., to bring about a more even cooling rate within the casting.

Another important aspect of the problem is that of the possible hindered contraction due to a riser or runner being held against the bars in the moulding box. The use of cores of too high dry-strength will result in cracked castings, and they will prevent the metal contracting to its fullest extent. Machin has recently shown this effect in a cylinder casting using a strong core reinforced with irons, the iron contracted $\frac{1}{16}$ in. whereas a weaker core resulted in a contraction of $\frac{1}{8}$ in. It is therefore advisable to use friable cores and break up the sand to allow the free contraction of the metal.

Displacement of cores may often result in a slight thickening of some portions of the casting and may also lead to cracking.

The author's thanks are due to the Director and Council of the British Cast Iron Research Association for permission to publish this Paper.

Catalogue Received

Aluminium Ingots and Billets. A four-page illustrated leaflet issued by the British Aluminium Company, Limited, of Adelaide House, King William Street, London, E.C.4, sets out in the clearest possible manner the standard shapes, sizes and weights of supply, including notched bars, aluminium-silicon ingots, half-round sticks and sections for either wire drawing or rolling.

Budgetary Control and Standard Costs

III.—CASE OF ATTACHED AND JOBBING FOUNDRIES

By T. McALPINE

(*Concluded from page* 176.)

Extent of the Budget System

The Production and Cost Budgets dealt with so far have been confined to castings only and to operations performed on them up to the cleaning stage. Where the foundry is attached to an engineering concern it may be the policy of the management to consider all cleaned castings delivered to the engineering side of the business as foundry sales. Any further operations on these castings and their assembly into the finished product would be excluded, therefore, from the foundry budget system. The manufacture of motor cars provides an example of this application.

In the manufacture of stoves, ranges, grates, and the like it is usually better, however, to treat all departments, including the assembly department, as sections of the foundry, and to make the budget system embrace all the activities of the business. It will, therefore, be necessary to consider what further budgets are required to link up production control from the cleaned castings stage to the assembly of the finished products.

These further operations will consist of (*a*) work done on castings, *e.g.*, plating and enamelling; (*b*) producing parts other than castings, *e.g.*, sheet metal parts, etc., and (*c*) the assembly of all components to produce the finished article.

A production and cost budget will be made out departmentally for each product, and where the work of a department consists of operations on castings, then the Castings List previously illustrated can be used for this purpose. Columns will be arranged to show the material, labour and oncost against each casting. The Production and Cost Budgets of those departments which make parts other than castings will take a different form, as illustrated in Form 10.

Form 10 will also serve for the assembly department, except that the labour charge will be shown in one total instead of against each part. It will be understood that the material consumption shown on the above budget will have to be included in the purchases budget if this budget is being operated. Labour will likewise be included in the payroll budget, and so on.

PRODUCTION AND COST BUDGET FOR YEAR ENDING 19 .

PRODUCT. DEPARTMENT: Sheet Metal Shop.

Drwg. No.	Name of part.	No. off.	Description of material.	Dimensions.	Weight.	Material cost.	Labour cost.	Oncost.	Total cost.
					T. C. Q. Lb	£ s. d.	£ s. d.	£ s. d.	£ s. d.

Form 10.—*Production and Cost Budget for Departments making Parts other than Castings.*

Budgeting for Jobbing Foundries

In most jobbing foundries it will not be possible to budget in detail, and before budgeting can even be considered, records should be available to show the sales, production and cost figures relating to previous periods. In budgeting for sales, each foundry will have to determine what is a reasonable tonnage to assume as the annual output (or other period decided upon) and what would be a fair sales price per ton.

It should not be a difficult matter to estimate these figures with close accuracy if previous sales records are available. As jobbing foundries can only produce against orders received, the sales tonnage will be the production output, so the only matter left for consideration is the question of production costs.

The natural division of costs is:—(1) Factory Costs, (2) Administration Expenses, and (3) Selling and Distribution Expenses, and all these expenses can generally be estimated fairly closely from the figures relating to previous periods. Factory Cost, to be correctly ascertained, must be treated departmentally, and the cost of operating any department should be collected under the following headings:—(*a*) Direct Labour; (*b*) Indirect Labour; and (*c*) Oncost Expense. If desired, Oncost Expense can be sub-divided to show fixed and variable expenses.

The direct and indirect labour charges can be based on the wages paid for previous periods. Factory Oncost, Administration, and Selling and Distribution Expenses can be ascertained from the cost records of previous periods, or, failing this, from a careful analysis of the financial books.

Generally speaking, the attitude to be adopted when preparing a budget is: "We employ a certain number of men in the foundry, and with this number of men we are justified in expecting an annual output of . . . tons per annum. Our sales in the past have been . . . tons per annum at a sales price of . . . per ton, and this provides sufficient work to keep our workers fully employed. This output also produces sufficient income to enable us to run the foundry at a profit. If our sales decline, we can reduce the number of workers employed, but we cannot hope to reduce our oncost in proportion to the reduction in output. We must therefore concentrate on maintaining our sales at not less than budget level."

The fact that many jobbing foundries employ approximately the same number of men from year to year bears out the truth of this statement.

Form 11 gives an illustration of a budget which has been found suitable in practice.

FOUNDRY BUDGET FOR YEAR ENDING 19 .

	Tons.	Tons.	£ s. d.	£ s. d.	Per cent.	Per ton.
1. CUPOLA DEPARTMENT.						
(*a*) Pig-iron, etc.						
(*b*) Melting materials						
(*c*) Labour						
(*d*) Variable expenses						
(*e*) Fixed expenses						
(*f*) Laboratory expenses						
Total cost						
Less melting loss						
Less scrap returns						
Net metal cost—Castings cleaned						
2. MOULDING DEPARTMENT.						
(*a*) Labour—direct						
(*b*) Labour—indirect						
(*c*) Variable expenses						
(*d*) Fixed expenses						
3. CORE DEPARTMENT.						
(*a*) Labour—direct						
(*b*) Labour—indirect						
(*c*) Variable expenses						
(*d*) Fixed expenses						
4. CLEANING DEPARTMENT.						
(*a*) Labour—direct						
(*b*) Labour—indirect						
(*c*) Variable expenses						
(*d*) Fixed expenses						
5. PATTERN SHOP.						
(*a*) Labour						
(*b*) Material						
(*c*) Variable expenses						
(*d*) Fixed expenses						
Total cost (factory)						
6. SELLING EXPENSES.						
Total expenditure						
Less defective castings (scrap value)						
Cost of good castings						
Less box parts, etc.						
Cost of castings sold						
Sales value						
Profit or loss						

Form 11.—*Budget Suited to the Needs of a Jobbing Foundry.*

The Attack of Hot Gases on Steel

In the course of an article in a recent issue of "Archiv für das Eisenhuttenwesen," E. HOUDREMONT and G. BANDEL state that in the study of the scaling of steel at high temperatures the first available facts consisted of isolated observations, but the scientific analysis of these observations and the significance of the various processes involved only followed at a later period. Industry has had at its disposal for some time an accumulation of these isolated results which have been reviewed and modified as systematic research led to a clearer understanding of the relevant phenomena. The following account shows how important it is for the evolution of new materials that a systematic investigation should be made of the mechanism operative in the scaling of metals by hot gases.

In an earlier Paper, the common alloying elements in steel were divided into groups according to their effect on the scaling of steel, and arising from this certain possible developments were suggested. The present Paper deals more with the structure of the scale itself, with alloy impoverishment at the surface, and with the influence of different gases.

Conditions Necessary for Scaling Resistance

So far as scaling is concerned the principal alloying elements in steel may be divided into two groups, those with a greater and those with a lower affinity for oxygen than has iron itself. To the former group belong Al, Si, Cr, Mn, Zr, Ti, V and N, and to the latter Cu, Ni, Mo and Co. A high resistance to scaling depends on the formation of an oxidised coating which will be denser than the coating formed on iron alone and which will be adherent and will, by resisting the penetration of the active gas, impede the further progress of scaling. Such oxide coating can be formed by the selective oxidation of alloying elements combined with the iron, the oxides of these elements having a higher heat of formation than that of iron oxide, and possessing a lower decomposition pressure at high temperatures. The elements of the first class mentioned above have the characteristics required, particularly Cr, Si and Al.

To fulfil the requirements of a low permeability for the attacking gas, good adhesion and mechanical density are desirable. In cases where a working range of temperature is frequently traversed the coating formed must not spall or crack. A coating with well-developed elastic or plastic properties would be very suitable, but as the oxides actually formed on iron alloys are generally of a brittle nature the demands of good adhesion are best met by an equality of thermal dilation between the oxide and the underlying metal and a total absence of physical transformations involving volume changes. The ideal condition is the formation of a very dense, thin, adherent coating in which any rupture is rapidly repaired.

Besides a freedom from mechanical defects due to stresses of thermal origin it is desirable that the coating should actually form under conditions that ensure freedom from porosity. In cases where the oxide film is naturally of a porous nature, it may sometimes be observed that a rise in temperature improves the continuity of the film and increases the protection afforded against further attack. For example, Fig. 1 shows the scaling loss in two silicon steels at various temperatures in air, and it is evident that a minimum in the rate of oxidation occurs in the range 700-900 deg. C. This unusual relationship is due to the sealing up of the scale by the sintering together of oxides and silicates.

The protective requirements of the film are, however, not completely satisfied by the condition of structural density. A very important condition is the greatest possible impedance to the diffusion of oxygen or other active gas towards the underlying metal on one hand, and a similar impedance to the outward diffusion of the alloy on the other. These factors are related, as is the sintering temperature of the oxide film, to the melting point of the oxide or silicate formed and to the melting point of the most fusible constituent of the scale. According to an approximation proposed by Tammann and Sworykin, free movement in the atoms of a compound, measured by the sintering of powders on heating, begins at a temperature of 0.5-0.6 of the absolute temperature of the melting point. In Table I the sintering temperatures and melting points of some compounds concerned in the present discussion are given. It will be observed that certain oxides, for example, those of iron, will permit increased diffusion at relatively low temperatures and will, therefore, form a feebly-protective scale. In an alloy steel it will be obvious that the controlling factor is the constituent of the scale possessing the lowest melting point.

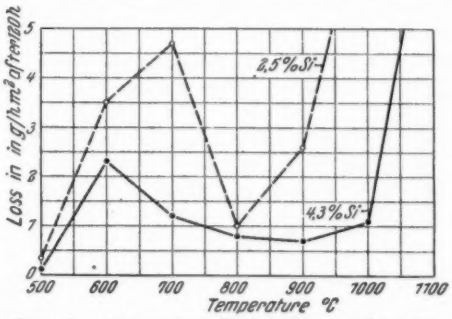


FIG. 1.—ANOMALOUS BEHAVIOUR OF SILICON STEELS WHEN SCALED IN AIR.

Certain other factors may interfere with the production of an effective protecting scale, among which are the formation of liquid or gaseous reaction products at the metal surface, either of which causes an enhanced attack. An example will be referred to later when considering the liquid-sulphide eutectics. It may be mentioned here that boron, or considerable amounts of molybdenum or tungsten, have an unfavourable effect on the scaling resistance of chromium and nickel-chromium steels. Boron causes liquid borates to form in the scale and molybdenum tends to accumulate under the scale and vaporises

TABLE I.—*Density, Melting Point, and Sintering Temperature of Some Metallic Oxides and Silicates.*

Formula.	Density. Gm. per cub. cm.	Melting point. Deg. C.	Sintering temp. Deg. C.
FeO	5.9	1,377	— 720
Fe_3O_4 ..	5.2	1,527	— 810
Fe_2O_3 ..	5.2	1,565	— 840
Cr_2O_3 ..	5.2	2,275	—1,260
SiO_2 ..	2.2—2.6	1,700	880
Al_2O_3 ..	3.9	2,050	1,160
$2FeO.SiO_2$ ..	—	1,205	— 615
$MnO.SiO_2$ ..	—	1,270	— 655

as the molybdenum "smoke" well known in the rolling of such steels. Other injurious influences are slag, enamel, salts, and vapour containing chlorides, all of which impair the protection afforded by the oxide film.

In the absence of any of these disturbing factors, and if a dense adherent oxide coating is formed possessing a limited capacity for diffusion, then true resistance to scaling is determined by an adequate rate of diffusion of the essential alloying constituent in the steel from the interior to the scale-metal interface, so that any oxygen that does penetrate the scale is immediately fixed by combination with this constituent.

If all these conditions be fulfilled and an equilibrium established between the penetration of oxygen through the scale by diffusion, and the migration of the alloy constituents outwards through the steel, then precise chemical analysis shows that the scale is predominantly composed of the oxides of the special elements with only a small proportion of iron oxides. In good protective scales the iron oxide is present either dissolved in the other oxides or as a compound such as silicate or spinel (*e.g.*, $FeO.Cr_2O_3$). Thus in the white scale produced by heating to 1,200 deg. C. in air, a steel containing 23.7 per cent. Cr and 7.5 per cent. Al, the composition of the scale was 94.5 per cent. Al_2O_3, 3.4 per cent. Cr_2O_3, and 2.0 per cent. Fe_2O_3.

On the other hand, if the equilibrium conditions are not realised, it is possible for oxides to form which have a lower affinity for oxygen than those of the special elements present. In cases where iron oxide is formed in addition to the oxides of chromium, silicon and aluminium, the high gas permeability of the former leads to increased attack. The scale is then similar to that found on pure iron by Pfeil and consists of three layers, ferrous oxide, magnetic oxide and ferric oxide, in which the oxides of the alloying elements are distributed in a definite way. The oxides of the protective metals are found chiefly in the inner zone, which consists of ferrous oxide (wüstite) as shown in Table II. A true protective action cannot be exerted, however, as the iron oxide dilutes the other oxides to such an extent that the high gas and metal permeability of pure ferrous oxide is approached and outside the inner zone of scale practically pure iron oxides are found. In manganese steels it is only with high proportions of this element that the manganese in the scale is concentrated in the inner layers. Manganese has a much greater affinity for oxygen than has iron, but the two oxides form a perfect series of solid solutions with each other, and

TABLE II.—*Enrichment of Alloying Elements in Inner Layer of Scale after Scaling in Air at* 1,000 *deg C. (Pfeil).*

Element.	Per cent. in steel.	Per cent. in scale.			Condition.
		Outer.	Middle.	Inner.	
Ni ..	2.75	—	0.16	7.1	Metallic.
Ni ..	36.0	1.46	2.29	52.1	,,
Cr ..	12.2	0.6	1.1	23.3	Oxide
Si ..	2.0	Tr.	Tr.	4.4	,,
Mn ..	3.1	1.5	2.6	2.5	,,

thus the same conditions regarding diffusion in the scale apply to both, and manganese is oxidised along with the iron.

If under the conditions above described there are elements alloyed with the iron that have a lower affinity for oxygen than iron itself, then these tend to concentrate at the scale/metal interface. This applies to the metals of the second group mentioned earlier, and confirmation is given in the last column of Table II. This process does not materially affect the progress of oxidation and no protection is afforded by the presence of the metallic layer under the scale.

The conditions governing the formation of a protective scale or the formation of a three-zone scale of iron oxide with little protecting power having been described, it remains to be said that both conditions can occur in the same steel, leading to local blisters of scale. An adequate diffusion of the effective elements to the scale/metal interface depends on the concentration of these elements, on the nature of the alloy, on the structure, and naturally, on temperature. A fully-effective supply may break down if, in a steel with a moderate alloy content, the oxygen permeability of the scale increases rapidly with rise of temperature. Further, it is to be remembered that, in the course of time, a loss of the protective constituents occurs, a process that is greatly accelerated by the spalling of the scale due to temperature changes or removal by mechanical damage. For instance, the preferential oxidation of aluminium in steel at high temperatures is very marked. A sheet of steel 0.08 in. thick, containing 20 per cent. Cr, 2 per cent. Al and

1.3 per cent. Si, had its average aluminium content reduced by 30 per cent. after heating at 1,200 deg. C. in air for 500 hrs. Similarly, a wire, 0.2 in. in diameter, containing 20 per cent. Cr and 5 per cent. Al, lost 85 per cent. of the

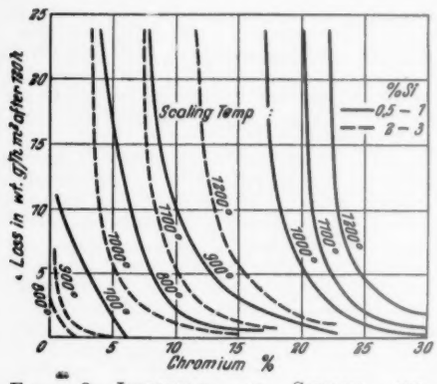


FIG. 2.—INFLUENCE OF SILICON AND CHROMIUM CONTENT ON RESISTANCE TO SCALING IN AIR.

aluminium after 500 hrs. at 1,300 deg. C. At corners and protruding fins this impoverishment occurs very rapidly and the formation of iron-oxide scale is facilitated. Thus, under severe conditions of exposure, such a steel latterly loses some of its intrinsic resistance to oxidation, and finally may attain the characteristics of a chromium steel without aluminium, the loss of the former element not being so marked.

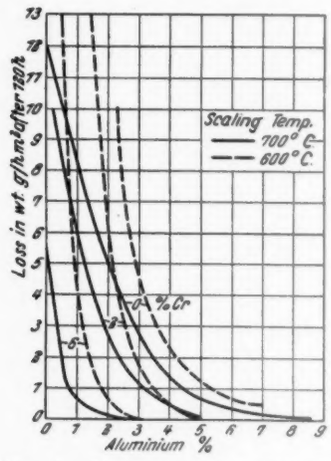


FIG. 3.—INFLUENCE OF ALUMINIUM AND CHROMIUM CONTENT ON RESISTANCE TO SCALING IN AIR.

Besides the direct consequences of alloy impoverishment there have to be reckoned certain indirect possibilities. Thus it may be that the partial removal of a constituent from the steel changes the structural condition of the metal, say, from ferrite to austenite, or *vice versa*, and such a change involves a change in diffusion constants and in volume.

A local disturbance of the diffusion equilibrium can also be induced by defects in the steel. If iron oxide is already present on the surface in an overlap, in the rolling skin, or in a defective weld, this cannot always be completely reduced by the outward diffusing alloy metal and healing does not take place, with the result that continuous rapid oxidation ensues. Inclusions and internal defects in the steel, even when these contain no oxide, can also interfere with the diffusion process and may produce a diffusion "shadow" on the surface.

The above consideration of the subject, based on fundamental chemical reactions as well as on the known properties of heat-resisting steels, might appear to be of doubtful practical value, since industrial gases frequently contain no air or oxygen, and may contain gases having a very different effect on steel. In some cases industrial atmospheres affect certain steels more and others less than does heated air. In all such cases, however, the foregoing explanation facilitates a complete understanding of the processes involved.

The experimental method adopted in determining the scale-resisting properties of a metal has a great influence on the numerical result obtained, and it may be as well to say here that all the figures quoted hereafter refer to a total time of 120 hrs. at the testing temperature divided into 24-hr. periods, after each of which the specimen was allowed to cool. At the end of 120 hrs. the scale was completely removed by a suitable solvent and the loss in weight determined. In Table III is given a list of the most common heat-resisting steels in use in Germany, with their compositions and the highest permissible service temperatures. Examples of the improvement in properties brought about by some of the most effective additions are shown in Figs. 2 and 3.

TABLE III.—*Composition of German Heat-Resisting Steels.*

Type.	C Per cent.	Si Per cent.	Cr Per cent.	Ni Per cent.	Al Per cent.	Mo Per cent.	Max. service temperature. Deg. C.
Cr–Si	0.10	2.0	3.0	—	—	—	750
Cr–Si	0.10	2.0	6.0	—	—	0.5	900
Cr–Si	0.30	1.5	30.0	—	—	—	1,200
Cr–Si–Al ..	0.10	0.4	6.0	—	0.8	—	800
Cr–Si–Al ..	0.10	1.2	24.0	—	1.8	—	1,200
Cr–Ni–Si ..	0.20	1.5	22.0	9.0	—	—	900
Cr–Ni–Si ..	0.15	2.0	20.0	15.0	—	—	1,050
Cr–Ni–Si ..	0.25	2.0	28.0	10.0	—	—	1,200
Cr–Ni–Si ..	0.15	2.0	25.0	20.0	—	—	1,200
Cr–Ni	<0.10	0.5	20.0	78.0	—	—	1,250
Cr–Ni	<0.10	1.0	18.0	60.0	—	(7)	1,150
Cr–Al ..	<0.10	0.5	20.0	—	5.0	—	1,300
Cr–Al	<0.10	0.5	30.0	—	5.0	—	1,300

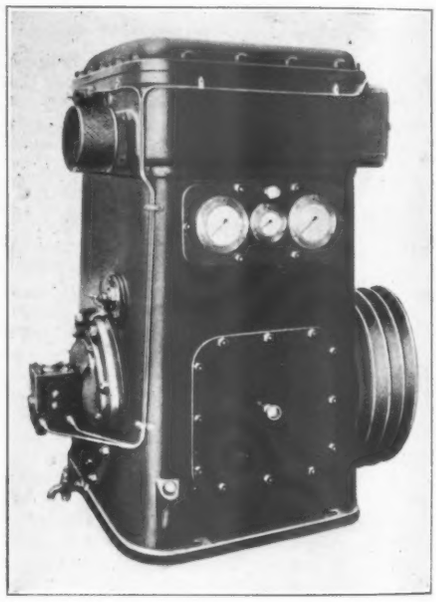
In addition to aluminium and silicon as valuable additions to chromium steels, nickel is also used to a very large extent. It is to be noted that the use of this metal, which improves the scaling properties of pure iron only very slightly, results in a great improvement in these properties when it is associated with chromium. This result is evidently brought about by the formation of a spinel of nickel and chromium oxides which produces a very coherent scale with a lower oxygen permeability than the scale on nickel-free iron-chromium alloys. The improvement due to nickel is not confined to the scaling properties, however, and the mechanical properties, the working properties and the welding properties are all simultaneously bettered, and the creep strength is raised as a consequence of the stabilisation of the austenitic structure.

(To be continued.)

THE ENGLISH ELECTRIC COMPANY, LIMITED, has bought premises at Thornbury, Bradford, for extensions to its Phœnix Works.

Monobloc-Type Compressor for Small Outputs

The compressor illustrated is the model "M" Monobloc type made by J. Browett Lindley (1931), Limited, Letchworth, Herts, and has been designed to meet the demand for small outputs, special attention having been directed to the object of providing an extremely efficient machine in a very compact form. Every working part is contained within the frame of the machine, including the flywheel. This renders the compressor particularly suitable for use in dirty or dusty atmospheres. The valves are of the automatic-plate type, with small lift and giving negligible wear. The valve chambers and covers are watercooled, a unique feature which increases overall efficiency and prevents the danger of overheating. All bearing surfaces are exceptionally large, and the crankshaft flywheel forging is mounted on large tapered rollers. A gear pump is mounted at the end of the crankshaft for the purpose of supplying oil under pressure to all working parts. A separate mechanical lubricator for the cylinders is mounted externally. An Auto-Klean oil strainer is provided, which can be cleaned by a turn of the handle whilst running, without danger of grit reaching the bearings.



MONOBLOC TYPE COMPRESSOR.

An intercooler is built into the cylinder block, being easily accessible for cleaning by removal of a side cover. An efficient filter is provided to safeguard the air supply and prevent excessive wear. This is also easily removable for cleaning. The drive can be by vee rope, chain, belt or direct coupling.

Correction of Brasses for Zinc Losses

In the May-June issue of Foundry Practice and Foseco News—the house organ of Foundry Services, Limited, of 285, Long Acre, Nechells, Birmingham, 7—just received, there is printed an extremely useful nomograph. It has five scales, and is used for charge compositions in brass foundry practice, the range embracing alloys containing from 53 to 71 per cent. of copper. The publishers, realising that for a nomograph a detailed sheet is preferable, are offering to send it in such a form to readers free of charge. The working out of the details of the chart is due to Mr. G. T. Salinger.

The Import Trade of the Argentine Republic

CONTINENTAL PRICE CUTTERS INJURING BRITISH FOUNDRIES

The Report* which Mr. Stanley G. Irving, C.M.G., has made upon the Economic and Commercial Conditions in the Argentine Republic is of profound importance to many branches of the United Kingdom foundry industry. It indicates the serious nature of the competition in many sections, and shows how, with others, the taking out of Argentina patent specifications is essential, and finally how local stocking and extended credit can help. The following are extracts, taken from the Report, germane to the foundry industry.

Cast-Iron Pipes

The volume of the imports of cast-iron pipes is governed by the orders placed by the Argentine Sanitary Works Department, the merchant trade being supplied by the national industry. During 1937, 5,643 tons were imported, as compared with 13,815 tons in the year before. The United Kingdom share was only 1,000 tons, cheaper prices enabling the Continent to supply the rest. It seems that United Kingdom manufacturers will continue to make a poor showing in this market, as a contract for 10,000 tons of pipes required by the Argentine Sanitary Works Department has already been placed with Continental firms in 1938. Cast-iron pipes will shortly have to meet severe competition from locally-made asbestos cement pressure pipes, a patent for their manufacture having recently been obtained by a newly-formed Argentine company which is putting up a local factory.

Valves

Whereas the sale of United Kingdom brass valves and fittings improved by roughly 20 per cent., Germany, with cut prices, took the lion's share of the business in cast-iron valves and fittings. Some small orders for valves required by the Irrigation Department went to the United Kingdom, but the principal Government buyers, the Argentine Sanitary Works Department, obtained their supplies from German manufacturers.

Cast-Iron Cookers and Stoves

Stoves.—Each year competition from local manufacturers is intensified. There are at least four factories producing stoves with a vitreous enamel finish which are offered at prices considerably below those of the imported article, and consequently sell well in this market, where cheapness is all-important. Anthracite stoves of United Kingdom origin and of a well-entrenched brand, backed by good propaganda and special service, continue to enjoy a steady sale. The market is, however, restricted by the rapid progress of central heating.

Ranges.—Gas, super-gas and electric stoves are nearly all made in the country from enamel-finish steel sheets. Solid-fuel ranges for coal, wood, etc., are also made cheaply by local factories, but "estancieros" continue to order established makes of imported cookers of good-quality cast iron throughout.

Heat Storage Cookers for Anthracite Fuel.—These are now on the market, but heavy Customs duties render them rather expensive, suitable mainly for high-class houses, and their progress is slow.

Heating and Cooking Apparatus

Gas production continues upward, and though no major plant extensions are contemplated for the current year by the Primitiva Gas Company which supplies the Federal Capital, this company will probably invite tenders for additional equipment in 1939. During the past ten years the market for United Kingdom gas-using appliances, at one time excellent, has dwindled more and more until to-day their importation has practically ceased. The type has fallen definitely out of favour with the public because of its rather old-fashioned appearance, while the high Customs duties on the finished article make the final cost prohibitive when compared with that of the local product—designed almost entirely on United States of American lines.

Railway Materials

The British railway companies, who account for 64 per cent. of the total railway mileage in Argentina and buy nearly all their requirements of foreign materials in the United Kingdom through their London offices, were obliged during the years of depression to reduce their purchases to indispensable replacements. An improvement in the outlook towards the close of 1936 and the good prospects for 1937 led to a revival in their foreign purchases, their aggregate imports from the United Kingdom in 1937 amounting to £3.9 million—or nearly 20 per cent. of the total United Kingdom exports to Argentina—as compared with £3.4 million in 1936 and £2.9 million in 1935. Nearly half of these totals, however, consists of coal, which represents £1¼ to £1½ million, the remainder largely comprising frames, bogies, wheels and axles for rolling stock, Diesel coaches, locomotives and parts thereof, machine and other tools, steel in various forms, etc. In view of the comparative failure of the 1937-38 cereal harvest and the consequent sharp fall in railway receipts, the British companies will no doubt again whittle down their purchases of materials.

The Argentine State Railways, after a policy of retrenchment and reorganisation between 1932 and 1934 embarked on a programme of expansion which has been steadily carried out during the past three years. Though they buy locally as far as possible, they make important purchases abroad, especially of iron and steel materials.

Heating and Air Cooling Plant and Accessories

The demand for heating and air conditioning plant was fairly well maintained as the building trade continued active. Cut-throat competition, however, forced contractors to pare costs to such an extent that prices for *central-heating installations* left hardly any profit. United States of America manufacturers retained their virtual monopoly of the growing market for *air-conditioning plant*, a position which they owe largely to the fact that the standard plant used in the United States of America meets the local requirements. Argentine Government Departments recently placed several important contracts in that country for plant to be installed in public buildings, United Kingdom manufacturers apparently being unable to supply suitable refrigerating plant and the necessary accessories to compete with the United States of America product. The imports of *radiators* increased from 1,201 tons in 1936 to 2,112 tons in 1937, but United Kingdom manufacturers had little or no participation in this trade, the principal supplying countries being Belgium and Germany. Steam radiators are also being made locally.

Agricultural Machinery

After several years of depression, satisfactory crops and greatly enhanced prices for all his products at last in 1937 enabled the Argentine farmer to undertake long-overdue replacements of all kinds of agricultural implements and machinery. Sales as a whole were practically double the 1936 figures, and most striking improvement occurring in tractors and harvester threshers, imports of which increased nearly fivefold and threefold respectively.

The United Kingdom has participated successfully in the growing trade in implements such as riding ploughs, tractor ploughs of four and five furrows, disc and tooth harrows, windmills and potato diggers. Threshers and portable steam engines, in which the United Kingdom once did a good business, have been almost entirely replaced by harvester-threshers and tractors, and it is regrettable that United Kingdom manufacturers have shown no apparent interest in supplying the rapidly expanding market for these items. Maize shellers are now made locally and sold at prices with which the imported article cannot compete. Tractors are supplied almost exclusively by the U.S.A. So far as is known there is only one firm in the United Kingdom manufacturing a tractor suitable for this country, and their f.o.b. price is approximately equivalent to the net selling price charged to the Argentine farmer for a similar U.S.A. product. United Kingdom prices for implements, although increased, are still competitive, but any further rise would affect sales seriously. United Kingdom manufacturers should also pay close attention to the delivery question, many orders having been lost owing to delay in supplying.

Serious crop losses make it difficult to estimate the prospects for 1938. In view, however, of the country's need for more agricultural machinery and of the fact that many farmers have carried forward surplus funds from last year, the turnover in 1938 may not fall far short of that of 1937. The future participation of the United Kingdom manufacturers in this trade will depend upon their ability to offer the Argentine farmer, at competitive prices, the type and quality of goods he requires and to guarantee prompt deliveries. Competition from the local manufacturers is increasing every year, especially as regards harvester-threshers, binders and headers, although it is rather an exaggeration to call these machines locally made since they are assembled largely from imported parts.

Textile Machinery

Spinning Machinery.—Cotton.—1937 was a fairly satisfactory year for the importation of United Kingdom cotton spinning machinery as several mills were extended and some new ones erected. Little competition was encountered, only a very few U.S.A. and Swiss spindles being imported. United Kingdom manufacturers' prices were competitive and their machines just what the market required. Towards the end of the year over-production created a crisis in the spinning industry and all interest in new plant disappeared pending regulation of output which is now under discussion.

Wool.—Polish and German manufacturers, selling at much cheaper prices and offering longer terms for payment than United Kingdom firms, obtained most of the orders, in spite of the recognised superiority of the United Kingdom machinery which is of a higher grade than is demanded by this market. Trade was slack towards the close of 1937 and yarn prices fell considerably. Several important firms went into bankruptcy and it will be some time before the demand for new equipment revives.

Silk.—Argentina's first viscose artificial silk mill—Ducilo S.A.—was inaugurated in 1937. All the plant for this factory, which was built jointly by United Kingdom and U.S.A. interests, was imported from the United States of America.

Weaving Machinery

Cotton.—The importation of cotton looms, especially of the automatic type, increased in the first half of 1937, but orders fell off in the later months though most mills continued to work full time: output has since been cut down owing to trade depression. Most of the looms imported come from the United Kingdom and it is ex-

* No. 705, issued by the Department of Overseas Trade. Published by H.M. Stationery Office, York House, Kingsway, W.C.2. Price 3s. 6d. net.

pected that when the local situation improves more looms will be required and that the larger mills will be forced by steadily growing competition to buy the automatic type only.

Wool.—Very little progress was made with machinery of United Kingdom manufacture owing to high prices, the bulk of the orders going to Germany. A few Belgian looms were also imported. As with cotton, 1937 began busily, but a reaction set in later and many looms were stopped. Machines were purchased on credit by numerous commission weavers whose activities added to the surplus. Many of these small firms are in difficulties and it seems doubtful whether they will survive the recession.

Artificial Silk.—Business in this section also declined towards the end of the year, and nearly 25 per cent. of the looms were stopped. Imports were restricted mainly to a few Swiss, Italian and French machines. In March, 1938, the largest mills were working two shifts a day as compared with three shifts in 1936, and a considerable time is likely to elapse before the silk weaving industry returns to its former activity.

Other Machinery

Hosiery and Knitting.—The market being already saturated with hosiery and knitted wear, the only imports in this class were a few automatic United Kingdom hosiery machines for producing the Morley type of half hose and some French and German knitting machines.

Braiding.—Most of the braiding machinery came from Germany, the United Kingdom supplying only a small quantity.

Finishing.—It is estimated that this trade was shared as follows: 50 per cent. to Germany, 40 per cent. to the United Kingdom, and the remaining 10 per cent. between Italy and the U.S.A. Imports of finishing machinery improved in 1937 to satisfy the growing requirements of the local mills, which are likely to place fresh orders as soon as conditions improve. Competition is keen and purchasers, not being well acquainted with the performances of the different makes, are inclined to order more on price than on quality.

Summing up, prospects are that, owing to the excess local production of textiles, imports of all kinds of machinery for the industry during the first six months at least of 1938 will be negligible. Possibly two years may pass before the demand again becomes active.

Electrical Machinery and Appliances

The general prosperity experienced in Argentina in 1937 was reflected in larger purchases of electrical goods, and on occasions the demand in many lines exceeded the available supplies. Constructional activity increased with the erection of numerous important buildings, both public and private, requiring large quantities of electrical equipment, while in addition to the many new factories several old ones were extended. Though the partial failure of the crops at the end of the year led to the suspension of much new business, the constructions already authorised, together with the increasing popularity of electrical appliances, should serve to sustain the consumption of electrical goods as a whole until the approach of the next harvest. If that is satisfactory, a revival in demand is anticipated. United Kingdom manufacturers participate very little in the material required in connection with electrical installations owing to the general use by this market of cheap types not produced in the United Kingdom. It is therefore the more regrettable that they have lost business in the heavier types of plant on account of increased prices and long deliveries. Competitors have also raised their prices, but not to the same extent.

Industrial Plant.—There was a substantial demand for electric motors and other equipment required for the development of a number of new local industries. United Kingdom manufacturers obtained a good share of the business owing to the exchange difficulties experienced by some of their competitors. Some important orders were placed for standard sizes of static transformers and house meters, but in most cases United Kingdom prices were not competitive.

Domestic Electrical Appliances.—The sales of domestic electric appliances improved appreciably as a result of the more prosperous conditions ruling throughout the country and the extension of electric supply services to new zones. In spite of the price advantage of at least 30 per cent. enjoyed by locally made articles, the turnover of imported appliances, mainly from the U.S.A. and Germany, showed a satisfactory increase, a large section of the public preferring to pay the difference for the better-quality imported product.

Flour Mill Machinery

The total sales of all kinds of imported flour mill machinery during the season July, 1936 to June, 1937, were again disappointing and probably did not exceed £60,000, unremunerative prices for flour obliging the millers to restrict their purchases to a minimum. Business during the first ten months of the period July, 1937 to June, 1938, was even more unsatisfactory, the total turnover being placed at no more than £35,000. United Kingdom machinery held its own against the usual competition from Germany and Switzerland. Prospects are now a little brighter in view of the recent official standardisation of types of flour which may stimulate the less efficient millers to improve their plants.

Grain Elevators

As the National Grain and Elevators Commission no longer grants permits for building them, the construction of private elevators has been brought to a standstill, and interest has centred on the national grain elevator scheme. Contracts for the first group of six terminal elevators were awarded early in 1937 and a United Kingdom firm secured the orders for the machinery for four of them, a German firm being successful in the other two cases. The adjudication of the contracts for the second group, comprising five elevators, was announced in February, 1938, two of the orders for machinery going to a local firm, two to a German firm and one to a Swiss firm. Tenders for the third group, comprising three elevators, are now being studied but it seems doubtful whether any of the orders will be placed in the United Kingdom. If not the latter's share of the total value of all the machinery contracts, *viz.*, approximately $33 million pesos, would be slightly less than 30 per cent. The proposal to construct 320 country elevators may, it appears, be shelved for the time being.

Mineral-Water Machinery

Imports of United Kingdom mineral-water machinery during 1937 advanced markedly compared with the preceding year, in spite of severe competition from the Continent and the local industry, the latter offering at $2,500 pesos a replica of a United Kingdom product the landed cost of which was approximately $3,500 pesos paper. So far only the smaller machines which command a ready sale have been copied but no doubt the practice will be extended in due course to the larger machines. It is essential therefore that United Kingdom manufacturers should protect themselves by registering their patent rights in this country without delay.

Sugar Machinery

In spite of the crisis in the local sugar industry and severe German competition based on long credit, United Kingdom manufacturers of cane-sugar plant did most satisfactory business, securing several unusually large orders, and they could have had even more business if they had been able to accept it on the specified delivery terms. A steady volume of inquiries should be forthcoming in future as a provisional agreement has been reached regarding sugar production and sales, pending the passage of a national law to regulate the industry.

Internal-Combustion Engines

Imports of internal-combustion engines, except those of the gas type, showed a notable increase over 1936, but most of the orders went to the Continent and will continue to do so unless United Kingdom manufacturers can reduce their prices appreciably and offer extended credit. With regard to the trade in general there are two factors which may tend to check progress: (1) the high charge recently imposed in the Buenos Aires district for reserve connections to the mains of the electricity supply companies, and (2) the increase in the price of Diesel fuel oil, which now costs $90 pesos per ton, as compared with $40 two years ago.

Oil Engines.—Fierce competition from foreign manufacturers, principally Germany, did not give United Kingdom exporters much opportunity of participating in the increased trade during 1937. So far as can be ascertained, all the important Government contracts were awarded to Continental firms whose local selling prices for oil engines over 100 h.p. were well below the landed cost of United Kingdom products. During the second half of the year German competition was keener than ever and recently U.S.A. 20-40 h.p. multi-cylinder high-speed vertical four-stroke oil engines appeared on the market. They are offered as Diesel engines, although some of them start on petrol and automatically switch over to gas oil, the equipment embodying the Bosch system and radiator cooling. These engines are mounted on skids and are frequently used on farm tractors. They are sold at prices about 20 per cent. below the landed cost of a similar United Kingdom type.

Petrol Paraffin Engines.—Sales went up nearly 50 per cent. during 1937, and, notwithstanding the poor crops, prospects for 1938 are fairly good as regards the smaller sizes up to 6 h.p. Little business was done in the larger sizes, which are being rapidly superseded by small vertical high-speed oil engines.

Gas Engines.—There was practically no market for gas engines, but a further rise in the price of diesel fuel oil might revive the demand for them and also for steam engines.

Machine Tools

Business in United Kingdom machine tools was poor last year, being almost restricted to purchases by the British railway companies and other British undertakings, the former placing comparatively few orders in view of their financial plight. Government Departments awarded nearly all their machine-tool contracts to Continental manufacturers, who underquoted their United Kingdom competitors and offered quicker deliveries. Local merchants continued to stock Continental machine tools almost exclusively.

Windmills and Pumps

As a result of the great improvement in agricultural and pastoral conditions, the imports of windmills jumped from 1,628 tons in 1936 to 2,619 tons in 1937, in the face of increased competition from local manufacturers. Although the U.S.A. again occupied a predominant position, local agents of United Kingdom windmill manufacturers at last succeeded, after hard work, in obtaining a good footing. It is understood that one British railway company recently standardised on a United Kingdom model. Nearly all the windmill towers are now made locally. Imports of pumps rose from 780 tons in 1936 to 983 tons in 1937. Local manufacturers almost control the trade in hand-made pumps, imports being confined to better quality pumps for general service which are imported chiefly from the United Kingdom and the U.S.A. Cheaper prices enabled the U.S.A. and Germany to supply most of the deep-well turbine pumps.

In 1937 the necessary machinery, apart from a few simple appliances made in the country, was again obtained almost entirely from U.S.A. manufacturers, who specialise in the type required in Argentina. It is doubtful whether the imports from the United Kingdom comprised more than a few rollers and concrete mixers.

Cast Iron Research and the Gas Industry*

By J. G. PEARCE, M.Sc., M.I.Mech.E., F.Inst.P. (Director and Secretary, British Cast Iron Research Association)

Service Requirements

Cast-iron alloys interest the gas engineer from four service aspects, involving mechanical strength, heat-resistance, corrosion-resistance, and wear- or erosion-resistance. Service requirements dictate the choice of material, which in some applications is comparatively simple, while in others mutually antagonistic requirements necessitate a compromise. Progress in each of these directions is indicated, and possible applications will be sufficiently evident to render elaboration at this stage unnecessary.

Mechanical Strength

Mechanical strength is of primary interest to the plant designer, and the use of tensile or transverse strength figures affords the readiest means available of comparing irons among themselves. Furthermore, provided the structures remain similar, an increase in strength does generally imply an increase, not necessarily a proportionate increase, in hardness and wear-resistance, and to some extent, also in heat- and corrosion-resistance, although for wear-, heat- and corrosion-resistance of a high order, structures other than those most convenient for ordinary mechanical requirements are preferable.

Testing.—Mechanical tests are readily taken and a given test represents an inherent property of the material, which is virtually independent of the conditions of testing, but great difficulty is experienced in finding criteria for heat, wear- and corrosion-resistance, for these do not represent inherent properties, but properties which vary with and depend upon external conditions. They are largely functions of conditions of application and these vary so widely that simplified and accelerated laboratory tests, useful as they may be in indicating what may profitably be tried under service conditions, are less reliable guides than actual service trials.

Furthermore, service conditions often involve two or more properties, such as heat and wear, or heat and corrosion, each of which affects the other in a way only indicated by a service type of test, advantageous as it may be to conduct this under the controlled conditions associated with a laboratory test. Test results quoted for these properties in this Paper, or noted elsewhere, should be taken as illustrative only, the actual material recommended for a given application being made only after careful consideration of all relevant details. Such details are often very difficult to obtain, the operating conditions frequently differing from those that are believed to operate, and examination of an actual failure is always a useful preliminary step. Improved service life must always be considered in relation to any additional cost incurred in achieving it.

What Cast Iron Is

The ferrous alloys usually considered as cast irons are essentially alloys of iron and carbon, containing more carbon than the steels. The dividing line between the two is not precise, and while in pure iron-carbon alloys a carbon content of 1.7 per cent. is regarded as the upper limit of the steels, it may in commercial alloys fall to 0.8 per cent. and yet yield a cast-iron structure, verifiable by the microscope, on account of the presence of other elements of composition.

Ferrite.—Pure iron, illustrated commercially by electrolytic or wrought iron, consists of grains or crystals of the soft, ductile material metallurgically termed ferrite. Carbon causes the formation with some of the iron of iron carbide, termed cementite, but when present in small quantities, as in mild steel, the cementite forms with the ferrite, according to the amount of carbon present, grains of an aggregate consisting of fine laminæ of both constituents, termed pearlite.

Pearlite.—This duplex structure behaves up to a comparatively elevated temperature as a simple material, and is harder, stronger and less ductile than ferrite. The actual carbon content of pearlite is about 0.9 per cent., so that steels below this figure are aggregates of ferrite and pearlite grains, and at this figure are wholly pearlitic. The pearlite of cast iron is structurally identical with that of steel, although the ferrite portion may contain hardening elements, such as silicon, in solution.

Cementite.—If the content of carbon increases still further, cementite exists in the free or massive condition, and at 6.6 per cent. carbon the whole structure would consist of hard, brittle cementite. Cast irons seldom contain more than 3.6 per cent. carbon, but a pure iron-carbon alloy of this carbon content, or a commercial cast iron of low silicon content or chilled in manufacture, has the hard, brittle property associated with the predominating cementite constituent.

White Iron.—These so-called white irons have their uses for certain types of service, in spite of their brittleness, and they also form the first stage in the manufacture of malleable cast irons, the white castings being annealed to yield a soft and ductile material consisting, according to initial composition and annealing cycle adopted, of a matrix of ferrite or pearlite, or both, with graphite in the nodular, temper-carbon form.

Malleable Cast Iron

Malleable cast irons are covered by British Standard Specifications Nos. 309—1927 and 310—1927, the former relating to whiteheart, which normally tends to be pearlitic, and the latter to blackheart, which normally tends to be ferritic. Minimum values for these irons are given in Table I.

TABLE I.—*Minimum Values for Malleable Cast Irons.*

	Ultimate tensile strength. Tons per sq. in.	Elongation on 2 in. Per cent.	Bend test.
1	2	3	4
Whiteheart (B.S.S. 309)	20	5	45 deg.
Blackheart (B.S.S. 310)	20	7½	90 deg.

For maximum values, the pearlitic matrix of whiteheart usually gives higher strengths and the ferritic matrix of blackheart higher ductilities, up to 18 per cent. Modern methods of manufacture are tending to minimise the traditional distinction between the two types of material, and strength and elongation depend upon requirements, although higher strengths are obtained at the expense of ductility and vice-versa.

Grey Iron

In the manufacture of grey iron, the task of the founder is so to adjust the composition and thickness of the casting, which jointly determine the structure formed, the latter through its influence on the rate of cooling, as to produce a machinable material. This involves the elimination of free carbide. The conversion to iron and graphite of carbide in excess of that required to form pearlite is accomplished by the use of silicon. The use of excess silicon, in order to guard against risk of unmachinability, yields a structure of ordinary cast iron consisting of ferrite and pearlite, the carbide of some of the pearlite also having been converted to iron and graphite. Such an iron may have tensile strengths of 9 to 12 tons per sq. in.

Pearlite is finer in some irons than in others, and the duplex structure is only revealed at a higher degree of resolution. Sulphur is usually combined with manganese present as comparatively harmless inclusions of manganese sulphide, and an excess of manganese over that required for sulphur removal is beneficial. The amount of phosphorus present will be governed by engineering, founding and economic considerations, and British blast furnaces offer users a wide range of pig-irons from the hematites, almost phosphorus-free, to the phosphoric pig-irons containing 1.5 per cent. phosphorus.

Fully-Pearlitic Irons

A closer degree of metallurgical control enables fully-pearlitic irons to be obtained stronger than the mixed structures. Pearlitic irons consist wholly of pearlite, broken by small patches of phosphide and graphite flakes. Such irons have tensile strenths of 12 to 18 tons per sq. in. and up to 20 tons per sq. in. with the alloy additions referred to below. The strength of cast iron is governed in part by the properties of the matrix and in part by the size and distribution of the flakes, and by a new foundry technique in which an iron which would otherwise be white is treated in the molten state by a graphitising agent, higher strengths are obtained, largely through a finer graphite structure. These so-called inoculated irons are also pearlitic. They have tensile strengths of 22 to 26 tons per sq. in., and in special cases a strength of 30 tons per sq. in. has been approached. Two such irons are well known as Meehanite and Ni-Tensyl.

High-Duty Irons

High-duty irons, both plain and inoculated, frequently contain alloy additions of such elements as nickel, copper, chromium and molybdenum. Nickel and copper may be used in part to replace silicon, which, although softening by breaking down carbide, has an intrinsic embrittling action on the matrix, while nickel and copper harden and toughen, and break down free carbide without affecting that of pearlite. Chromium and molybdenum are carbide stabilisers which not only strengthen pearlitic irons but enable them to resist elevated temperatures by postponing carbide breakdown. Carefully-made alloy irons are sound, dense and uniform, and for these reasons also resist thermal and corrosive attack better than plain irons. Compositions are carefully balanced to suit the strength required in a given section.

Heat-Treated Cast Iron

By thermal treatment on lines not dissimilar from those used for steels, the mechanical properties of cast iron may be further increased, by about 15 to 20 per cent. for the high-duty irons and about 5 per cent. for ordinary irons. The limit of tensile strength for heat-treated cast iron may be regarded as about 33 tons per sq. in. This is a full heat-treatment and must not be confused with the annealing used for stress removal or with the softening treatment (conversion of pearlite to ferrite) used to facilitate high-speed machining. If low-carbon alloy cast iron is cast in the white state and heat-treated, the flake form of graphite is suppressed in favour of the nodular temper-carbon form, and tensile strengths up to 50 or 60 tons per sq. in. are obtained. Structurally such irons would contain pearlite with free cementite, and after heat-treatment the pearlite assumes the spheroidised form, the metal consisting of finely-divided spheroids of carbide in a matrix of ferrite. The production of such metal is clearly

* Extracts from a Paper presented to the seventy-fifth annual general meeting of the Institution of Gas Engineers.

related to that of malleable cast iron referred to previously, but it is lower in carbon and makes considerable use of alloy additions, and intermediate strengths may be obtained by suitable composition and treatment. These irons are finding application for such exacting service as crankshafts, camshafts and brake-drums in the automobile and general engineering industry.

Capacity for Distortion

While ordinary pearlitic cast iron cannot be described as a ductile material, it has greater capacity for distortion under stress than is realised by many engineers. The deflection in transverse serves as a criterion, and that part of this deflection represented by permanent set, usually some 20 per cent. of the total, is an index to capacity for resisting shock or impact. Under alternating stress, fatigue or vibration, cast iron behaves well compared with other metals, as the quality called into play is lack of notch sensitivity rather than ductility.

Grey Iron Castings

Table II summarises the general-purpose grey irons now covered by British Standard Specifications, of which No. 321-1938 covers Grades A and C of ordinary engineering iron, while Grades 1, 2 and 3, as specified in No. 786-1938, cover high-duty irons.

TABLE II.—*Strengths of Grey Iron Castings.*

Test-bar diameter. In.	Representing section. In.	Ultimate tensile strength. Tons per sq. in.				
		Grade A.	Grade C.	Grade 1.	Grade 2.	Grade C.
		B.S.S. 321-1938.		B.S.S. 786-1938.		
1	2	3	4	5	6	7
0.6	Up to 0.375	12.5	10	—	—	—
0.875	0.375 to 0.75	12	10	15	18	22
1.2	0.75 to 1.125	11	9	14	17	20
1.6	1.125 to 1.625	10.5	9	13	16	19
2.1	Over 1.625	10	9	12.5	15	18

HEAT-RESISTANCE

Effect of Heating and Cooling

When a cast iron is heated, ordinary uniform thermal expansion (about 1.4×10^{-5}) takes place, and at about 760 deg. C. a marked constitutional change occurs. At this temperature the carbide of the pearlite dissolves in the ferrite to form a solid solution of iron carbide in iron, known as austenite. This change, without alteration in temperature, is accompanied by a marked contraction in volume. On increase of temperature, any free cementite or graphite begins to dissolve in amounts dependent on the temperature (the maximum amount is 1.7 per cent. carbon at the melting point) and thermal expansion continues.

On cooling the reverse change takes place, the graphite or cementite (in grey or white iron respectively) being re-precipitated. The constitutional change usually occurs at a slightly lower temperature than on heating and is accompanied by an expansion. The expansion on cooling is further augmented by some breakdown of pearlite into ferrite and graphite, a change accompanied by an increase in volume. Such a cycle results in an overall increase in volume and may be termed the growth of the iron for that heating cycle, and will depend upon the extent of the decomposition of the pearlite; in other words, upon its stability.

Effect of Oxidation

When all the carbide is decomposed, the metal is completely ferritic, but growth can continue under heat because oxidation of the metal begins to take place internally through the penetration of hot gases into the graphite cavities; the change from iron to iron oxide is the cause of a decided volume increase, setting up a stress which sooner or later relieves itself in a minute crack, which offers further channels for gaseous penetration and oxidation. This produces the characteristic crazing or honeycomb cracking on the heated surface. The process is essentially one of oxidation identical with scaling on external surfaces, to which all ferrous materials are liable under appropriate conditions. Growth is greater the higher the temperature reached, the longer the time held at that temperature, the greater the number of fluctuations, and, in general, the higher the carbon and silicon contents of the metal and the coarser the flakes of graphite.

Many applications of cast iron involve submission to elevated temperatures, steady or fluctuating, regular or intermittent. The conditions to be met are generally, although not invariably, oxidising. Where the conditions involve the sudden rise in temperature, such as is found in the case of the ingot mould subjected to the thermal shock and sudden stress due to the impact of molten steel, a high-carbon iron with flake graphite, low in phosphorus, is found most suitable, although such an iron is liable to growth on account of the rather open structure, fairly high silicon and coarse graphite. To harden the iron, however, by lowering the silicon and reducing the graphite size, tends to provoke failure by cracking, and the best arrangement is essentially a compromise in which failure by growth is the natural end, since failure by cracking occurs, as a rule, before failure by growth.

Under oxidising conditions, the choice of an iron will depend upon whether it needs to be machinable; upon the conditions of heating; the cost or ease of replacement (including cost of keeping the plant standing); and the presence of corrosion or erosion. For severe conditions it is often simplest to replace the cheapest type of iron as often as is required, for it must be clearly understood that heat-resisting irons, other than the high chromium irons referred to later, do not melt at higher temperatures, but resist oxidising conditions better than ordinary irons. Of these irons, five categories are available.

White Irons

Where machinability is not required and brittleness is not a handicap, white irons may be used. The high-carbon white irons contain more cementite, and hence are harder and more brittle, than the lower carbon white irons, and the carbide may be stabilised by chromium and/or molybdenum. Such irons contain no free graphite and hence do not grow, but under severe conditions they are liable to scale. They are often suitable under combined heat and erosion. Further reference is made later to wear-resistance.

Grey Irons

Ordinary machinable grey irons, particularly if sound, dense and close-grained, can be rendered more resistant to heat by a small addition of chromium or molybdenum. The use of nickel with chromium renders change in the silicon content unnecessary, in addition to aiding soundness and uniformity. Such irons should not be used above 700 deg. C., as this is nearing the pearlite change. Phosphorus is usually present as a hard, rigid phosphide network throughout the metal, and this may serve to keep the structure rigid, but above 900 deg. C. the phosphide rapidly becomes plastic. Grey irons retain their mechanical properties well at elevated temperatures, usually being only slightly weaker at about 250 deg. C. and keeping their air temperature strength up to 400 deg. C. The thermal conductivity of pearlitic iron depends somewhat on composition and falls slightly as temperature increases. It may be taken as 0.11 to 0.14 unit at 100 deg. C. The use of pearlitic irons is advised where temperatures are moderate and mechanical strength is desirable.

High-Silican Irons

This type of iron is low in carbon and high in silicon and was developed by the British Cast Iron Research Association (British Patent 323,076). It contains 4 to 10 per cent. of silicon and about 2.5 per cent. of carbon, and consists of fine graphite and ferrite. There is no carbide to break down, the silicon makes the metal highly resistant to oxidation, and the small quantity of fine graphite (due to the low carbon) prevents the ingress of oxidising gases. The silicon also raises the constitutional change to over 900 deg. C., up to which temperature these irons may be regarded as suitable. The most serious disadvantage of the material, which is relatively cheap, is its brittleness, although at operating temperatures it is much better in this respect than at air temperature.

Aluminium confers considerable heat-resistance on cast iron, and has been used in Silal, but aluminium cast iron is not easy to make into sound castings. Development of a range of aluminium cast irons is now proceeding in the British Cast Iron Research Association's laboratories under the name Cralfer.

Austenitic Irons

By means of alloy additions it is practicable so to lower the pearlite change point that it is reduced below atmospheric temperature, and such irons are austenitic in the cold state. Structurally they consist of comparatively fine graphite in austenite, with or without chromium carbide, depending on whether or not any chromium is present. These irons are markedly different in properties from the pearlitic irons, for they are very soft and ductile, have quite good mechanical properties, and are non-magnetic, in addition to having the wear-, heat- and corrosion-resisting properties referred to later. They take a high finish and have a thermal expansion rather higher (1.8×10^{-5}, compared with 1.4×10^{-5} for pearlitic iron) and a thermal conductivity rather lower than pearlitic iron. They retain their strength and rigidity at elevated temperatures to a much greater extent than ordinary cast irons and steels.

The first austenitic iron made, Nomag, is used essentially for its non-magnetic properties. Two have been developed for corrosion- and heat-resisting purposes, Ni-Resist and Nicrosilal, the latter a development of Silal, by the British Cast Iron Research Association (British Patent 378,508). Such irons have no critical change, because there is no pearlite point above air temperature, and thus they cannot be hardened by heat-treatment. Approximate compositions are given in Table III.

TABLE III.—*Approximate Compositions of Heat-Resisting Irons.*

	T.C.	Si.	Ni.	Cu.	Cr.	Mn.
1	2	3	4	5	6	7
Silal ..	2.0 to 2.5	4.5 to 6.0	Nil	Nil	Nil	0.5 to 0.8
Ni-Resist ..	2.7 to 3.1	1 to 2	13 to 15	5 to 7	1.25 to 4.0	1 to 1.5
Nicrosilal ..	1.5 to 2.0	4.5 to 6.0	18 to 20	Nil	1.5 to 4.0	0.5 to 1.0

Nicrosilal containing less than 17 per cent. nickel and more than 5 per cent. silicon is liable to change in part to martensite in the temperature range from 500 deg. C. to 700 deg. C. The result of ten heats of three hours' duration at 950 deg. C., from tests made by Vickers-Armstrongs, Limited, Barrow-in-Furness, on two high-quality engineering irons, structurally similar to a fully pearlitic grey iron, and Nicrosilal of low and high chromium content, showed that the engineering irons grew 70 and 40 per cent. respectively in volume (21 and 11 per cent. in weight), while the former Nicrosilal decreased 2.5 per cent. in volume and the latter increased 0.4 per cent. Both decreased in weight, 5 and 1.3 per cent. respectively. Slight non-adherent scale caused the drop in weight.

By suitable compositions and/or a rapid rate of coolings, castings can be made of martensitic structure, being hard and unmachinable, but having some very suitable applications. For present purposes martensite can be regarded as a form of austenite having, however, very different properties.

The cost of austenitic irons is a handicap to the wide use which their special properties justify, but they should be considered where the highest degree of combined machinability, strength, and resistance to heat, wear and corrosion is desired.

High-Chromium Irons

Iron-chromium alloys containing up to 13 per cent. chromium are highly resistant both to heat and corrosion and formed the early stainless steels. Carbon, however, is essential to ensure castability in a cast metal, and forms chromium carbide at the expense of that chromium required to dissolve in the matrix and confer resistance to corrosion. This can be overcome by using further chromium to combine with the carbon present, and castable alloys can be made with 1 to 3 per cent. carbon and up to 35 per cent. chromium. The amount of carbon depends upon conditions of manufacture, but for a machinable material, 2 per cent. carbon should not be exceeded, although both raw materials and manufacturing costs increase as the carbon falls.

These irons, while not generally so highly resistant to corrosion as the high-silicon irons (15 per cent. Si) used in the chemical industry, offer better resistance to heat than any other iron and will resist temperatures up to 1,100 deg. C. Of special interest to the gas industry is the fact that these irons offer the best possible resistance to sulphur and sulphurous gases, hydrogen sulphide, sulphur dioxide and sulphur trioxide. Structurally they consist of ferrite and carbide.

The tensile strength of these irons is about double that of an ordinary engineering iron, and this value increases slightly up to 500 deg. C. Their ductility is about that of ordinary cast iron, but they are harder to machine. Molybdenum enhances the resistance of the iron-chromium alloys against attack by some reagents.

Properties of Heat-Resisting Irons

The properties of the specifically heat-resisting materials may be summarised as in Table IV. Table V has been published by N. P. Inglis,[1] but the 35 per cent. chromium irons are not included in the last entry:

Effects of Thermal Shock

Reference has been made to the effects of thermal shock. The comparative brittleness of the alloys high in silicon, aluminium or chromium may cause difficulty where metal is required to withstand sudden and considerable temperature changes, which, of course, result in mechanical stress due to expansion and contraction, or where a steep thermal gradient exists. Under these conditions a hematite iron offers the best service, and the higher the carbon and graphite content, the greater will be the thermal shock resistance. To illustrate this point, four bars of Nicrosilal of various compositions, two of Silal and two of hematite, were repeatedly heated to 700 deg. C. and quenched in water. After four of these severe quenchings, the Silal bars showed small, but visible, cracks. After ten quenchings the Nicrosilal bars developed cracks, while the hematite bars withstood a dozen quenchings,

TABLE IV.—*Properties of Heat-Resisting Materials.*

	Silal type.	Austenitic type.	High-chrome type.
1	2	3	4
Tensile strength, tons per sq. in.	10 to 12	15 to 25	25 to 30
Tensile strength, tons per sq. in. at 800 deg. C. ..	2.5	3.5	7
Elongation, per cent.	Nil	2 to 3	Nil
Thermal expansion	1.4×10^{-5}	1.8×10^{-5}	1.4×10^{-5}
Thermal conductivity: Units at 100 deg. C.	0.088	0.070	—
Units at 430 deg. C.	0.082	0.063	—
Brinell hardness ..	180 to 300	150 to 300	250 to 350
Magnetic properties	As grey iron	Non-magnetic	As grey iron

although very badly scaled. The bars were holed and notched to see whether these would originate premature local cracks, but this was not the case. Heat-resisting irons, even when comparatively brittle in the cold, are much tougher at operating temperatures, when ordinary machinable

TABLE V.—*Temperature Resistance of Heat-Resisting Irons.*

	Temperature at which serious deterioration occurs (growth and scaling). Deg. C.	Temperature at which appreciable scaling occurs. Deg. C.	Recommended maximum for practical use. Deg. C.
1	2	3	4
Ordinary cast iron	500	500	450
Pearlitic cast iron ..	650	500	550
1 per cent. chromium cast iron ..	750	550	600
Silal (4 to 10 per cent. Si)	900	800	750
Nicrosilal and similar high Cr and Ni-Cr cast irons	No change up to 1,000	900	950

irons are apt to become plastic. Thus a bar maintained at 850 deg. C. and loaded cantilever fashion at one end gave a deflection of 1.9 in. in four days in the case of a pearlitic iron, 0.32 in. in the case of Silal and 0.08 in. in the case of Nicrosilal.

(To be continued.)

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Aluminium as a Desulphuriser

According to W. I. KARMASIN in "Teori. prakt. met." aluminium may be used as a desulphuriser for steel after adequate pre-deoxidation, liquid aluminium sulphide being formed. The partition coefficient is about 125 with mixtures of Al_2O_3 and Al_2S_3 and about 10 with acid O.-H. slags.

Contraction Tests for Low-Melting-Point Alloys

With the object of finding a basis for standardisation, the German Society for Testing Materials has prepared a tentative method for ascertaining the contraction of low-melting-point alloys such as anti-friction metals melting below 700 deg. C. Fig. 1 shows the proposed type of mould, from which it will be seen that it is made up of three components 12 mm. wide, assembled by means of two 10-mm. dia. bolts. These plates, forming as they do the necessary cavity, are made of fine-grained pearlitic iron. Before being used they are dressed with a thin coating of clay and silicate of soda made into a thin paste with water. If it is thoroughly dried it will withstand several casts without scaling off. Obviously, the mould must be accurately machined, cleaned and maintained within a temperature range of 15 to 25 deg. C.

To make a test, 20 ± 1 cub. cm. of metal are cast into the horizontally set mould, protected on every side, including the base, by a

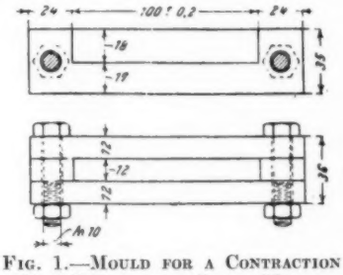

FIG. 1.—MOULD FOR A CONTRACTION TEST-PIECE FOR LOW MELTING POINT ALLOYS.

high-grade insulating material, to minimise heat losses. The metal should enter the centre of the mould, a tun-dish being used to guide it and it should be cast as quickly as possible. Slow cooling is the object sought. When the mould and the test-bar attain room temperature the length of the latter is measured to an accuracy of 0.01 mm. The difference between this figure and the length of the mould is expressed as a percentage of the latter figure, and gives the measure of the contraction of the alloy.

If it be desired to reproduce foundry conditions and the mould be used in a preheated condition, it is necessary that the expansion of the mould be taken into consideration before calculations are made. If layers show up, it indicates that a wrong casting temperature has been chosen and steps should be taken to correct this.

Publication Received

Monel Data Book I. Issued by Henry Wiggin & Company, Limited, Thames House, Millbank, London, S.W.1.

The reviewer has often wondered why people pronounce Monel, Mon*el*. The opening sentence of this publication provides the clue. It appears that the alloy takes its name from that of a former president of the International Nickel Company—Mr. Ambrose Monell. The book is of pocket size, and an effort has obviously been made to keep it within reasonable proportions—a matter of 88 pages—by using a wide variation in type size. The expert view is that a correct procedure has been followed, but a personal one is that the appearance of large type on the right-hand page and small italics on the left, as frequently occurs, reinforces the normal detraction associated with the left-hand page. From the feundry angle, this booklet is extremely useful, as not only are all the physical properties of the alloy detailed, but also there is a chapter on the welding of cast iron by Monel metal. The book is by courtesy of the publishers placed at the disposal of our readers free of all cost.

World Iron and Steel Production in January to June

GERMANY TEMPORARILY TAKES PREMIER PLACE

An estimate of the world's iron and steel production in January to June last compared with the parallel period of 1937, as calculated by the Wirtschaftsgruppe Eisen schaffende Industrie of Berlin, is given in the subjoined table. The output of pig-iron in Europe declined by about 330,000 metric tons, Germany registering an increase of over 1,000,000 tons, however; other advances were shown by U.S.S.R., Poland, Italy, Sweden, Spain and British India. Production in Great Britain showed an insignificant decline, while the declines in output in France, Belgium, Luxemburg and Czecho-Slovakia were fairly heavy. The total output for producing countries other than those in Europe was more than halved, mainly owing to the heavy fall in United States output. The world total as a result showed the very substantial decline of 12,700,000 tons as compared with the first half of 1937, or approximately 24 per cent.

Steel production followed a parallel course to pig-iron output, the figure for Europe showing a small reduction of 600,000 tons, with Germany registering an advance of 1,500,000 tons and Russia one of 500,000 tons. Germany thus becomes for the time being the world's principal steel producer. Small increases were shown by Italy, Poland, Spain and British India, and decreases in Belgium, France, Luxemburg, Great Britain, Czecho-Slovakia and Sweden. Production outside Europe fell by 19,000,000 tons or substantially more than half the 34,681,000 tons produced in the first half of 1937. The United States was again responsible for the major part of the decline, as steel production dropped by 18,600,000 tons to 11,215,000 tons. World production of steel ingots declined by nearly 20,000,000 tons or 27.5 per cent. as compared with the first six months of 1937.

Apart from the high level of production and demand in the first half of 1937 in all countries and the universal recession in export demand since September, 1937, which has persisted month after month, various influences have been responsible from case to case for the changes in January to June last as compared with the corresponding period in 1937. In all cases the export trade has been the cause of some recession in iron and steel output; in Germany this contraction has been more than made up by the expansion in home demand, mainly in connection with rearmament and large public-works programmes. Since the annexation of Austria, production in that country has been forced up in order that the iron and steel works in the new Ostmark shall contribute their meed to the German totals. Compared with January and February, Austrian production of pig-iron had advanced 50 per cent., of steel ingots 75 per cent., and of finished products 55 per cent. In Great Britain, the demand on the inland market has weakened, resulting in a decline of over 400,000 tons in steel output. France has suffered from a general stagnation of trade with persistent economic and currency troubles; Belgium and Luxemburg, largely dependent on the export trade, have felt the full force of the shrinkage in that trade. Demand in Czecho-Slovakia has languished with political troubles. The U.S.S.R., an economic unit virtually outside the frontiers of international trade, has continued the expansion of its iron and steel industry. Armaments demand enabled the Italian industry to show an advance in output.

In the United States, where the recession had its origin and has resulted in the furthest decline, steel demand slipped back at such a rate that weekly production figures have been below the lowest levels reached in the great recession following the 1929 boom year, and at the same time compelled the United States iron and steel industry to seek outlets in the international markets, with serious repercussions on the trade and export policy of the European Steel Cartel.

TABLE I.—*World Iron and Steel Production in January to June*, 1937 *and* 1938. (1 = 1,000 *Metri: Tons.*)

Country.	Pig-iron.		Steel.	
	1937.	1938.	1937.	1938.
Germany ..	7,710	9,040	9,562	11,316
Ostmark	153		310	
France	3,819	3,178	3,933	3,230
Great Britain ..	4,075	4,069	6,569	6,125
Belgium ..	1,860	1,203	1,871	1,087
Luxemburg ..	1,306	716	1,324	682
Czecho-Slovakia	806	698	1,105	993
Poland	339	430	677	718
U.S.S.R... ..	7,098	7,291	8,750	9,250
Italy	371	409	1,073	1,128
Sweden	319	348	548	453
Spain	12*	156*	20*	169*
Hungary ..	173	177*	300†	300†
Other countries..	562†	554†	721†	710†
Total: Europe	28,603	28,269	36,763	36,161
U.S.A.	20,422	8,118	29,811	11,215
Canada	464	411	729	615*
Japan	1,611	1,800†	2,991	3,000†
British India ..	827	874	470	481
Other countries..	467†	224†	681†	306†
Total: America etc. and Asia	23,791	11,427	34,681	15,617
World Total ..	52,394	39,696	71,444	51,778

* Partly estimated. † Wholly estimated.

In Japan, iron and steel output has been bolstered up by a heavy demand for armaments consequent on the China venture, as well as further expansion towards a position of partial self-sufficiency.

A recent study of the Institut für Konjunkturforschung calls attention to the headway made, particularly in the last decade, by the iron and steel industries in countries other than the six traditional producing countries, *viz.*, Great Britain, Germany, Belgium, Luxemburg, France and the United States, which may be distinguished as the Cartel countries in contradistinction to the remaining producers or "other countries." Between 1913 and 1929, world steel output increased by 45,000,000 tons, of which 80 per cent. was shared by the six Cartel countries, in fact, 15,500,000 tons was contributed by the United States, while in the nine years 1929-37 the whole of the increase of 14,000,000 tons was contributed by the other countries, and the production of the Cartel countries receded by 3,300,000 tons. The fundamental changes in the world's iron and steel industries which commenced to gain impetus after the War have thus become accelerated during the last nine years. The reason for this is, of course, the desire of many consuming countries to become independent of the principal producing countries, a phase of the pronounced trend towards industrial self-sufficiency. In 1913 the Cartel countries accounted for 85 per cent. of the world's steel output, and were still responsible for 84 per cent. in 1920, but last year their share had dropped to 72.6 per cent. During the same quarter-century the output from other countries increased from 11,600,000 tons to 37,200,000 tons, or from 15.1 per cent. to 27.6 per cent. of total world production. The U.S.S.R. is responsible for the increased representation of other countries, since between 1929 and 1937 alone steel production of the Soviet has increased from 4,700,000 to 17,800,000 tons.

TABLE II.—*Iron and Steel Exports in* 1913 *and* 1937. (*In* 1,000 *Metric Tons.*)

	Exports.		Percentage of production.	
	1913.	1937.	1913.	1937.
Great Britain ..	4,050	2,100	51.0	16.0
Germany* ..	5,100	2,650	27.0	13.5
Belgium* ..	1,350	3,700	54.0	58.0
France	550	1,950	12.5	25.0
United States ..	2,650	3,300	7.5	6.5
Total	13,700	13,700	—	—
Percentage of world steel output ..	20.9	13.8	—	—

* Luxemburg included with Germany for 1913 and with Belgium for 1937.

A direct consequence of the structural changes in the world's iron and steel industry has been a shrinkage of exports from the traditional producing countries. While steel consumption is estimated to have been 77 per cent. greater in 1937 than in 1913, steel exports of the six Cartel countries were roughly the same in both years, *viz.*, 13,700,000 tons, so that these countries have derived little benefit from the marked increase in world steel consumption. The main reason for this static condition, which is analysed in Table II, is, naturally, the absence of Russia as a steel importer. The contraction in export demand has led to a diversion of much increased tonnages to the respective home markets, notably in Great Britain and Germany, where, however, the demand has been so heavy that the supply has proved incapable of fully covering it. The need for an improved export trade remains an urgent problem in France, Luxemburg and Belgium, especially as France has since the war acquired the Lorraine industry, which needs an outlet, and Luxemburg has practically no inland market, since its incorporation in economic union with Belgium, where the expansion of steel capacity following the war has enforced the need for an active export trade.

New British Chemical Standards

The Bureau of Analysed Samples, Limited, advises us that two compositionally standardised samples are now ready for issue:—The first is a ferro-vanadium known as No. 205, and contains 52.2 per cent. of vanadium. The approximate percentage of other elements is as follows:—C, 0.16; Si, 1.18; S, 0.03; P, 0.05. The second standard is Ni-Cr-Mo steel "B." It has the following analysis (per cent.):—C, 0.35; Si, 0.25; S, 0.034; P, 0.024; Mn, 0.61; Ni, 3.05; Cr, 0.68; Mo, 0.34. The ferro-vanadium is a typical sample of the type of alloy appearing on the British market. It is also useful to chemists for the purpose of adding exact amounts of vanadium to standard steels to bring the vanadium to the required percentage for testing out methods of analysis.

The Ni-Cr-Mo steel has a composition similar to one of the typical specifications for this class of material. As usual, each standard has been analysed by a number of chemists representing independent analysts and chemists representing well-known manufacturers and users. Each purchaser will be provided with a certificate showing the analysis of each chemist and giving an outline of the methods he has used. In particular, modern methods for V, Cr, and Mo will be of special interest. The standards are issued in bottles containing 25 grms., 50 grms., 100 grms., and 500 grms., at prices estimated to cover the cost of production.

The standards may be obtained direct from Bureau of Analysed Samples, Limited, 3, Wilson Street, Middlesbrough, or through the usual laboratory furnishers.

Flame-Cutting of Cast Iron

By C. H. S. TUPHOLME

The principal reason for flame-cutting cast iron in preference to other methods is usually that of speed. The older methods for cutting this material, such as drilling, chipping or sawing, appear doubly tedious in comparison with the relatively short time required for doing similar work with the flame. Maintenance and demolition operations frequently require considerable cutting of cast iron. When production, for instance, is dependent upon the rapid completion of a repair job, the time saved by flame-cutting often makes the use of this process particularly valuable.

Often the size and situation of the part to be cut or removed may be such that no other method of severing the material can be utilised safely or expeditiously. In such instances, an added value of flame-cutting results from the fact that the equipment is readily portable, and the blowpipe can be used in cramped places. Cast-iron columns have been cut in sites where other equipment could not possibly be used. Parts of mining equipment in congested plants have been successfully cut out, altered or completely demolished where the time-honoured blasting method would have seriously jeopardised the plant building and other equipment.

The work can be handled in such a way that the sections to be removed, or the equipment to be demolished, can be cut without damaging attached parts. This feature becomes particularly important when removing pulleys, gears or flywheels that have been shrunk on forged steel shafts.

A Special Technique

Cast-iron cutting requires a somewhat different technique from that used in cutting ordinary steel, although the equipment is substantially the same. The difference lies mainly in the manipulation of the blowpipe, the flame adjustment, and in the handling of the work in general. It is a simple operation, although there is a slight knack to accomplishing satisfactory work. Proper instruction and some practice will enable the average operator to master the procedure quickly.

Under otherwise identical conditions, a cut in a piece of cast iron will produce a wider kerf, and the edges will be less smooth and even as compared with a similar cut in steel. A good cut in cast iron, particularly in heavy material, will have an appearance about equal to a fair cut in steel of similar thickness.

Those who already have oxy-acetylene cutting equipment, including a good general-duty cutting blowpipe and an oxygen regulator of sufficient capacity for the working of pressures necessary, require no other special equipment for the average run of work. It is advisable often to use an oxygen lance in conjunction with the blowpipe when cutting extremely large or heavy sections. It will usually be most convenient to have a portable outfit, mounted on a suitable hand truck that carries standard oxygen and acetylene cylinders.

Oxygen Supply

Where the work is to take place in a limited area, and the quantity or size of the work will require a considerable amount of oxygen, it may be found desirable to use a portable oxygen manifold, or for regular production work to have a permanent oxygen manifold installation. This will ensure an adequate and uninterrupted supply of oxygen, and eliminate extra motion in changing cylinders.

Slight differences in manipulation of the blowpipe are required for various grades of cast iron. Preliminary adjustment of the flame and the oxygen pressures remain the same. Lower grade metal requires more heat, and it will be found that the cutting will advance less rapidly because of the refractoriness of the graphite or other condition of the metal which tends to retard the rate of reaction. A wider kerf will be cut in poor metal than in metal of higher quality. This will necessitate wider limits to the blowpipe nozzle oscillation.

With reference to the good and the lower grades of cast iron, it should be understood that the better quality includes castings which have been or are to be machined, or castings known in foundries as "good grey-iron castings." On the other hand, ingot moulds, grate bars, castings that have been exposed to considerable heat, balance weights, floor-plates, chilled iron and other castings known in foundries as "furnace iron" or "low-grade castings," are for the purpose considered as low-grade cast iron.

For cutting low-grade castings with certain types of cutting apparatus, it may be advisable to get in touch with the manufacturer of the apparatus in order to determine whether a special cast-iron cutting nozzle is needed to give the increased heat required for this work.

As a preliminary to cutting cast iron, particularly in those cases where it is desirable to prevent warpage of the material, or where cutting is to be done with the greatest possible economy, it may be desirable to preheat the entire casting. If this be done, the casting, when cut, should be permitted to cool gradually under a covering of asbestos unless it is to be scrapped. The essential point to remember in the cutting operation itself is to maintain a steady and intense preheat at the starting point, as well as at the top of the cut. It is also necessary to keep the outflow of slag from the bottom of the cut as uniform as possible.

Type of Flame

While it is generally understood that an excess of acetylene in the flame is the best way to accomplish the job, opinions differ somewhat as to the exact amount of excess acetylene required. The consensus seems to be that an excess acetylene feather of 2 to 2½ times the length of the inner cone of the flame is best. Other operators, equally competent (and possibly due to their own slight differences in manipulation), maintain that less excess acetylene in the flame is sufficient. Still other operators believe that they are better able to perform this work satisfactorily with a neutral flame, particularly if a special nozzle is used for the work. While the majority of observers favour the excess acetylene condition, it would be, perhaps, best for those undertaking to learn how to do this work to try out various adjustments for themselves and standardise on the flame adjustment which seems to give them best results.

The first step is a preliminary preheating with the flame along the edge to be cut from the top of the section to the bottom. In other words, preheat what will be the first "bite" of the cutting flame through the entire thickness of the metal. The cut will start more quickly and more easily if this part of the casing is warmed up considerably. The warmer the whole mass of iron, the easier it is to start and maintain the cut. The practice of using a steel welding rod to start the cut, instead of preheating the vertical line of the kerf, has been found useful in some cases. The combustion of the steel rod supplies additional localised heat in the cast iron, and is said to make faster starting possible. The rod is generally used until the operator is assured that he can continue the cut in the casting without the aid of the extra heat.

Practical Hints

After the preheating and the preliminary warming of the line of cut is accomplished, hold the blowpipe so that the nozzle inclines at an angle of about 45 deg. away from the edge of the casting to be cut. The inner cones of the flame (not the excess acetylene cones) should be about ½ in. above the surface, according to the grade of metal being cut.

If the cut surfaces are to be kept soft for machining, they should be cooled slowly. Cover the hot ends with asbestos paper as soon as the cut is made, and do not knock off the slag scale until the metal is cold. If no machining be contemplated, the slag may be knocked off while still hot. No other cooling precautions would then be necessary, except where the possibility of warpage is a consideration.

In general, when working on low-grade castings, follow the procedure for good grade castings, with the exception that the blowpipe nozzle should advance more slowly. Do not open the cutting valve until the metal, being preheated, begins to boil. If the metal does not become fluid easily, feed in a steel welding rod, ¼ in. or $\frac{5}{16}$ in. in diameter, with one hand while holding the blowpipe with the other. Only a few inches of steel rod are necessary. Its use will be found more economical than heating another puddle in order to get started. The oxidation of the rod supplies additional heat where needed; and, furthermore, the molten oxidised steel acts as a flux for the slag. The process is therefore a type of "flux cutting."

Flux cutting is not limited to starting cuts on low-grade cast iron. Should a cut at any time threaten to go dark, use steel to keep it going. It is well to keep steel welding rod or thin pieces of steel such as old barrel hoops handy at all times for this purpose.

Aluminium Used

If a tough adherent layer of slag forms on the metal in the kerf, and prevents further oxidation, drop sparingly some aluminium shot into the kerf. Usually no more than two handfuls are necessary even for a large mass of iron. The aluminium acts as a flux to make the slag more fluid, and thus enables the cutting to continue. The oxidation of the aluminium also supplies additional heat. Crushed silicon or ferro-silicon may sometimes be used instead of aluminium as a fluxing material. The choice of flux depends on the nature of the particular slag. If the first one tried does not work, try another.

Extra heavy work requires special consideration. It is of particular importance to allow room for the escape of molten slag. Forethought in this regard will make the job easier, cleaner and more economical. If the part of the casting to be cut is raised a little from the ground, and placed upon blocks, the outlet for the slag will be adequate, and the cutting operation will be found to progress more smoothly.

Risers or other large sections must be cut in a warm condition whenever possible. A saving in gas consumption is thereby effected, any tendency towards warping is counteracted, and the cut surface remains soft for subsequent machining if it is cooled slowly.

Oxygen Lance Cutting

A most important modification of the cast-iron cutting technique for use on heavy sections is the use of the oxygen lance in conjunction with the cutting blowpipe. This method is frequently employed for cutting large sections of cast iron such as hammer bases, or for dismantling heavy machinery. The oxygen pressure at the regulator for the lance depends largely upon the grade of cast iron to be cut, and on the experience of the operator. An initial oxygen pressure of 40 lbs. per sq. in. can be tried, and this varied as circumstances warrant. The oxygen should never be allowed to rush out so rapidly as to chill the metal. A labourer should be employed to regulate the pressure, handle the oxygen cylinders, and change lance pipes.

Cutting cast iron is a much hotter job than cutting steel. There is a considerably greater abundance of sparks and slag. The operator should, therefore, wear heavy asbestos gloves and suitable clothing to protect the body, face and head. A shield, conveniently made by cutting a hole in a piece of asbestos paper and then slipping it over the head of the blowpipe up to the handle, will further protect the hands. Be sure also to protect the legs and feet well from the spattering of melted slag. This may be done by standing a ½-in. thick sheet of asbestos board in front of the work, or better still by wearing suitable protective leggings. If such leggings are worn, they should always cover the lace holes so that the slag cannot enter. It is always a good plan to use a fire brick as a hand rest if possible. This will make it easier to control the movements of the blowpipe.

Always make ample provision against heat and sparks before starting work, so that it will not be necessary to stop cutting to take shelter or to provide further protection. Hot metal cuts best, so do not delay and allow the work to cool.

Fire Precautions

If the cutting has to be done inside a building, care should be taken, wherever possible, to move any exposed combustible material a safe distance away, say 30 or 40 ft. If this cannot be done, the combustible material should be adequately protected from possible contact with sparks or hot slag. Use sheet metal guards or asbestos curtains, and be sure that no openings exist where these meet the floor, as hot slag may roll along the floor for considerable distances.

Be sure the floor is protected, if it be made of wood or combustible material, so that it will not take fire from the slag or hot globules of metal. Covering it with asbestos or sheet metal, or wetting it down with water are ways of doing this. A watchman should be stationed at the work, and he should remain for at least 30 min. after the operator leaves to be sure that smouldering combustible material does not remain. Adequate fire-extinguishing apparatus should be provided for every such job. If the work is indoors and a sprinkler system is installed, be sure that, wherever possible, the system is in operation and the water has not been turned off.

The type of cutting described above, essentially developed for cast-iron cutting, can also be used for certain alloy castings, and is found to be applicable to one or two types of alloy steel. White cast iron, with 2.50 per cent. carbon or more, can be cut by this method. Malleable cast irons ranging in carbon content up to 2.50 per cent. and silicon 1.00 per cent. are also easily cut. Acid-resisting iron which has about 15 per cent. silicon and only 0.75 per cent. carbon requires the cast-iron cutting technique.

There are two high alloy steels that can be cut by this method also. High-speed steel with carbon between 0.60 and 0.90 per cent., tungsten 10.0 to 20.0 per cent., chromium 5.00 per cent., and vanadium 2.00 per cent. can be cut using this technique. Cutting becomes impracticable, however, when the tungsten percentage rises above 20. High nickel steel having 0.50 per cent. maximum of carbon and 30.00 to 50.00 chromium with no nickel can be handled in this way also.

(*Continued from next column.*)

The tip speed of ventilating fans, forming part of a system of artificial ventilation, should not greatly exceed 50 ft. per sec. Ventilating ducts should be lined with sound-absorbent, and a length of canvas hose might advantageously be inserted at some point in a duct.

Copies of the issue of the Journal containing Dr. Kaye's full Paper are available from the Institute of Physics, 1, Lowther Gardens, London, S.W.7, price 2s. 8d. post free.

Noise Reduction in Modern Buildings

ELIMINATING STRUCTURE-BORNE SOUNDS

The modern building may be fireproof, but it is not noise-proof. In fact, measurements have shown it to be a good deal noisier than the traditional designs, where there was a discontinuity of structure, and massive but poorly-conducting materials. Steel-framed and ferro-concrete building, cement mortar and plaster, to say nothing of a general ramification of central heating, running water and other piping, have replaced the softer brickwork, lime mortar and plaster, wooden beams, joists and studding, and the localised piping of the older houses.

Dr. G. W. C. Kaye, of the National Physical Laboratory, who has just contributed an article to the "Journal of Scientific Instruments" on "Sound and Noise Insulation," says that if we are to mitigate the noise nuisance in modern buildings we must adopt measures which are best incorporated during the designing stage. There are, according to Dr. Kaye, two guiding principles when the question of noise and sound abatement is being considered: the one is that the degree of abatement of a noise in a particular locality need be no more than will conform to the background of noise which obtains in that locality. The other is that in a medley of noises, the loudest must be tackled first to achieve any appreciable benefit, after that the next loudest, and so on.

The first line of attack on noise abatement, and in general much the most effective and economical, is to tackle an objectionable noise at the source, and find the best means of reducing the output as much as possible. The next step is to find a method of confining or "smothering" the noise in the place where it is generated. The path of a sound in its journey from source to hearer may be either *via* the intervening air or *via* a sequence of solid materials or structures. Experience had shown that the two effects required very different remedies for abatement.

Large-scale operations require "sound-proof" buildings to mask them. Doors and windows should be heavy and close-fitting, and situated on the side remote from that where the noise is liable to be regarded as a nuisance. Doors and windows, particularly high windows and sky-lights, may require to be doubled and, in extreme cases, it might be necessary to employ double walls mounted on independent foundations.

The remedy for structure-borne noises is discontinuity somewhere in the structure either in the form of an air gap or as resilient material. Recent tests show that the insulating value of a single solid wall benefited by the application to both sides of plastered building board, fixed to batons secured by insulating clips.

Dr. Kaye describes three general methods providing a composite structure for floors. The first is to lay on the floor a soft material or linoleum with a sponge rubber backing, the second is to lay a "floating floor"—a supplementary floor supported on insulating material on the structural floor—and to mount an insulated false ceiling below the floor, for example, on insulating hooks. Each of these methods possesses its own advantages.

Machinery in a building should be mounted on an undamped elastic support so weighted and proportioned that the frequency of vibration of the machinery on this support was low compared with the frequency of the noise generated. Noise conducted through water pipes could be reduced by replacing a few feet of the pipe with rubber hose or by mounting the pipe with insulated clips.

(*Continued in previous column.*)

American Notes

(FROM A SPECIAL CORRESPONDENT.)

A Modern Pattern Shop

With several thousands of standard and special patterns, representing a total of well over 45,000 pieces, valued at approximately £100,000, the Driver-Harris Company, of Harrison, New Jersey, maintains what is probably the largest pattern storage in the American alloy casting industry. This inventory includes active designs only. Obsolete patterns are continuously being scrapped. An entire building is given over to pattern storage, and despite the widest range of shapes and sizes and purposes, a card-index system immediately locates any desired pattern for the foundry.

In making nickel-chromium castings for heat- and corrosion-resistance purposes, the firm maintains its own patternshop as part of its plant. Due to the peculiarities of nickel-chromium castings, patternmakers especially trained in this alloy foundry practice are best entrusted with patterns. To ensure uniform walls, especially those as thin as ¼ in. for large pot castings, the

A CORNER OF THE DRIVER HARRIS PATTERN STORE.

firm's practice calls for the almost exclusive use of core-boxes rather than relying on a pattern making its own core. The extra care in pattern-making permits of lighter pieces where lowest initial cost is a prime factor.

Patterns to be used many times are necessarily of better construction than the one-off pattern. The former must be carefully built of thoroughly kiln-dried wood such as selected pine and even mahogany, with parts screwed rather than glued or nailed together.

The foundry superintendent stated that good patterns pay in the long run, even though they may originally cost two or three times as much as the inexpensive one-off pattern. The finish of the casting depends on the pattern and this is another point considered in the production of the patterns actively in use.

In the Driver-Harris pattern storage there are many examples of good pattern workmanship. Some of the patterns, especially the large pieces for retorts, muffles, pots and normalising shafts, have been used for years, yet retain their accuracy and good finish for the making of fine castings.

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In the Special Areas — in Northumberland and Durham, Scotland, South Wales and West Cumberland — labour is plentiful, skilled and unskilled, male, female and juvenile. Transport communications are excellent, natural resources rich and varied. Conditions combine with Government assistance to give industry a start free from all encumbrances — the best start it has ever been offered in any country's industrial history.

*

IN YOUR OWN INTEREST, and that of the business you own or contemplate starting, you should know the full scope of these important schemes of assistance.

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For Scotland: at 13, Carlton Terrace, Edinburgh, 7; or 25, Victoria Street, London, S.W.1

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- Low Carbon Malleable
  (FOR MALLEABLE CASTINGS OF ALL DESCRIPTIONS)

Supplied to any specification between limits of 2·00 and 3·50% Carbon and ·50% and 3·50% Silicon

● **ACTUAL ANALYSIS CERTIFICATES ARE AVAILABLE WITH EACH DELIVERY**

● **Typical Cylinder Pig Iron Specification**

TOTAL CARBON	2·70%
SILICON	1·80%
MANGANESE	·90%
SULPHUR	·06%
PHOSPHORUS	·40%

● **Typical Malleable Pig Iron Specification**

TOTAL CARBON	2·60%
SILICON	·75%
MANGANESE	·50%
SULPHUR	·05%
PHOSPHORUS	·06%

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The Week's News in Brief

Trade Talk

DOUBLE SEAL RING COMPANY, an American firm, has taken premises on the Team Valley Estate.

THE 21ST BIENNIAL BUILDING EXHIBITION is to be held at Olympia from September 16 to October 1. It is to be opened by Sir Philip Sassoon, First Commissioner of Works.

THE REPORT of the Eire Revenue Commissioners for 1935, only issued now, reveals that for the period Customs duties levied on imported cast-iron manufactures reached the figure of £6,651.

IN VIEW of the present unsatisfactory state of the hematite pig-iron trade one of two furnaces in blast at the works of the Millom & Askam Hematite Iron Company, Limited, has been damped down.

WHAT IS CLAIMED to be an entirely novel anti-corrosive process, known as Roval, has been placed upon the market by International Corrodeless, Limited, of 46, Victoria Street, London, S.W.1.

CONSOLIDATED PNEUMATIC TOOL COMPANY, LIMITED, a company with headquarters in London, have set up a depôt on the Team Valley Estate in order to give a vastly improved maintenance service to local users of their tools.

THE SECOND ANNUAL DINNER of the Institute of Welding is to be held at Grosvenor House, Park Lane, London, W.1, on October 26. Sir William J. Larke, K.B.E., will preside and Sir Frank Smith, K.C.B., secretary of the Royal Society, and the Hon. Mr. Justice Langton, O.B.E., K.C., will be the principal guests.

WILLIAM CUMMING & COMPANY, LIMITED, of Kelvinside Works, Maryhill, Glasgow, is the first manufacturing concern in the Glasgow area to have completed an air raid shelter of the latest approved type. It consists of an underground chamber 56 ft. long by 7 ft. 2 in. wide and 7 ft. 3 in. high; and possesses toilet accommodation and decontamination chamber. Over it is a 2 ft. layer of concrete, then a depth of rubble, and finally 5 to 6 ft. of earth.

EVIDENCE OF INCREASING unemployment in the light castings industry is provided in figures contained in the half-yearly report of the Ironfounding Workers' Association. Mr. Hugh Murdoch, general secretary, writing in the name of the executive council, states that the membership at December 31, 1937, was 11,880, of which only 200 were then on the idle list; whereas at June 30, 1938, there were 1,080 idle out of a membership of 11,884. At the same period, 1,354 members were working only three days per week, while 1,373 were working four days per week.

"BIG BEN," with Boadicea's statue in the foreground, is a striking and appropriate decoration for a B.I.F. menu card, 195,000 of which will shortly be distributed in seven European countries; in the Argentine, Chile, and Brazil; in the British West Indies and British East Africa. In addition, this card, printed in nine languages, will be used on British and Continental airway lines and on cross-Channel and other steamship services to the Continent. Thirteen thousand illustrated cards, printed in eight languages, will be issued to nine countries, and 3,000 B.I.F. blotters are being sent to Italy for distribution to Italian firms.

IMPORTANT DEVELOPMENTS in British aircraft manufacture are announced. John Brown & Company, Limited, of Sheffield and Clydebank, have acquired from Petters, Limited, a controlling interest in Westland Aircraft, Limited. Lord Aberconway, C.B.E., Sir Holberry Mensforth, K.C.B., C.B.E., and Mr. S. W. Rawson, of John Brown & Company, have joined the board of Westland Aircraft, Limited, and Lord Aberconway has become chairman of the company in place of Mr. Alan P. Good, who, while resigning the position, remains a member of the board. Westland Aircraft, Limited, has, with the approval of the Air Ministry, purchased from Petters, Limited, the freehold lands and buildings adjoining the works at present occupied by Petters. By this acquisition the productive capacity of Westland Aircraft will be more than doubled and space provided for further extension of manufacturing capacity. The consideration for the purchase is the allotment to Petters, Limited, of 600,000 ordinary shares of 5s. each in Westland Aircraft, Limited. Activities other than aircraft production previously carried on at Yeovil are to be transferred to the Brush Company at Loughborough.

Personal

MR. L. S. MILLS has been appointed by Edgar Allen & Company, Limited, of Sheffield, as an additional representative attached to their subsidiary company in South Africa.

DR. T. SWINDEN, for his Paper on "Special Steels and Their Application to Engineering and Shipbuilding," has been awarded the M. C. James Gold Medal by the Council of the North-East Coast Institution of Engineers and Shipbuilders.

MR. JAMES A. MORRIS, chairman of the firm of Glenfield & Kennedy, Limited, is at present engaged in writing a book regarding the principal industrial undertaking in Kilmarnock. He is dealing with the subject from a personal rather than a technical point of view.

MR. CLAUD STURROCK, who has resigned from the South African Cabinet, is a native of Newport, Dundee, where his father was identified with the firm of Robertson & Orchar, with which Mr. Sturrock served his apprenticeship before going to South Africa in 1907. In Johannesburg he established the engineering firm of Sturrock's, Limited. He is President of the Association of Chambers of Commerce and a director of many undertakings.

MR. J. DENHAM CHRISTIE, chairman of Messrs. Swan, Hunter & Wigham Richardson, Limited, Wallsend shipbuilders since 1930, is resigning his position owing to ill-health, but will retain his seat on the board. He is being succeeded by Mr. Charles S. Swan, vice-chairman since 1931. Mr. Christie started his career as a shipbuilder with the old firm of Wigham Richardson & Company, Newcastle, and was elected a director in 1891. In 1903, when the firm merged with C. S. Swan & Hunter, and assumed its present name, Mr. Christie was elected a director. Mr. Swan, the new chairman, is a son of the founder of C. S. Swan & Hunter. Sir Philip Wigham Richardson has been appointed vice-chairman.

Obituary

MR. WILLIAM HARDING SCOTT, founder of the firm of Laurence, Scott & Electromotors, Limited, died on Sunday, September 4, at Norwich. Mr. Scott, who was 76 years of age, lost his younger son, at the early age of 27, only a week before. Mr. W. H. Scott had worked in and for the electrical industry during more than half a century, from the copper brush era to the present day. He went to Norwich to install electric light at Colmans Works, and remained in the city to found a business there in 1883. He very soon gained a reputation for really reliable dynamos and motors. The present extensive use of electricity on board ship owes much to Mr. Scott's work and engineering judgment. He was the pioneer of the marine electric motor and generator, designing machines specifically for such service. He invented the electric cargo winch, and lived to see it installed on many of the finest ships now afloat; and at the time of his death his company was making nearly 20,000 h.p. of machines for the "Queen Elizabeth."

Contracts Open

Ilfracombe, September 20.—3,300 yds. of 6-in. and 1,600 yds. of 4-in. spun-iron pipes, with a quantity of special castings, for the Urban District Council. Mr. A. J. Westaway, engineer, Council Offices, Ilfracombe.

Southwell, September 22.—Provision and laying of cast-iron water main extensions, for the Rural District Council. Mr. S. Cooper, surveyor, 8, Westgate, Southwell, Notts.

Pretoria, September 29.—Deep-well power head, centrifugal pump, etc., for the Public Works Department. The Department of Overseas Trade. (Reference T.Y. 26,529/38.)

The XIIIth International Acetylene Congress will be held in Munich from June 25 to July 1, 1939. London (1936) was the venue of the last Congress.

Company Reports

Radiation, Limited.—Interim dividend of 3½ per cent.

Modern Machine Tools, Limited.—Interim dividend of 7½ per cent.

Lancashire Dynamo & Crypto, Limited.—Interim dividend of 7½ per cent.

Worthington-Simpson, Limited.—Interim dividend of 3 per cent. on the preference shares.

Cammell Laird & Company, Limited.—Interim dividend in respect of 1938 of 4 per cent. on the ordinary stock.

Federated Foundries, Limited.—Dividend on the 5 per cent. preference shares for the half-year to June 30, 1938.

Triplex Foundry, Limited.—Interim dividend on the ordinary shares of 2½ per cent. on account of the year ending March 31, 1939.

Qualcast, Limited.—Profit for the year ended June 30, £80,070; final dividend of 10 per cent. and a bonus of 10 per cent., making 30 per cent. for the year.

Blakey's Boot Protectors, Limited.—Profit for the year ended June 30, after depreciation, £36,722; income tax and N.D.C., £12,715; net profit, £24,007; brought in, £5,742; dividend on the preference shares, £431; dividend of 15 per cent. on the ordinary shares, £13,329; carried forward, £15,989. Meeting, September 15.

Publications Received

A Modern Marvel—The Radiovisor Light-Ray in Operation. By Col. the Hon. Arthur Murray, C.M.G. Price 1s. 6d.

As will be gathered from the sub-title of this booklet, the subject matter deals with the photo-electric cell. Though the reviewer dislikes such expressions as "marvel" and "wonder," in this case it is felt that the appellation is justified so far as the layman is concerned. The applications the reviewer has personally encountered in foundry practice are (1) counting the moulds passing along a conveyor and (2) switching on and off the general lighting system. These are probably the minimum potential uses, as the book tells of numerous control gadgets such as tolerance detection, smoke prevention, oil burner and oil level control, turbidity indicators, and so forth. The particular instrument dealt with is the Radiovisor, which is manufactured by a company over which the author presides. Generally speaking, the subject matter relates to light-ray apparatus in general and, as such, makes interesting reading.

Transactions of the Manchester Association of Engineers, Session 1937-8. Edited by T. Makemson. Published by the Association, St. John Street Chambers, Deansgate, Manchester, 3.

A wide range of interesting subjects has been covered during the last session of this Association. Amongst these are notched-bar impact testing—a symposium which attracted world-wide interest; work analysis without a stop-watch; metal aircraft production; crystallography; engineering publicity; mining and optical measuring.

The outstanding lecturer of the year was Sir William H. Bragg, President of the Royal Society. There is the usual modicum of material in this year's Proceedings germane to foundry metallurgy, and some interesting points about corrosion-resisting metals are brought out in Prof. Thompson's Paper on "Some Modern Metallurgical Developments of Interest to the Engineer." The same Paper covers the subject of light alloys.

A CONTRACT has been obtained by the Metropolitan Vickers Electrical Company, Limited, for the electrical equipment of the new cold-rolling plant to be installed by the Whitehead Iron & Steel Company, Limited, at Newport, Mon. The contract for the mill itself has been placed with Davy & United Engineering Company, Limited.

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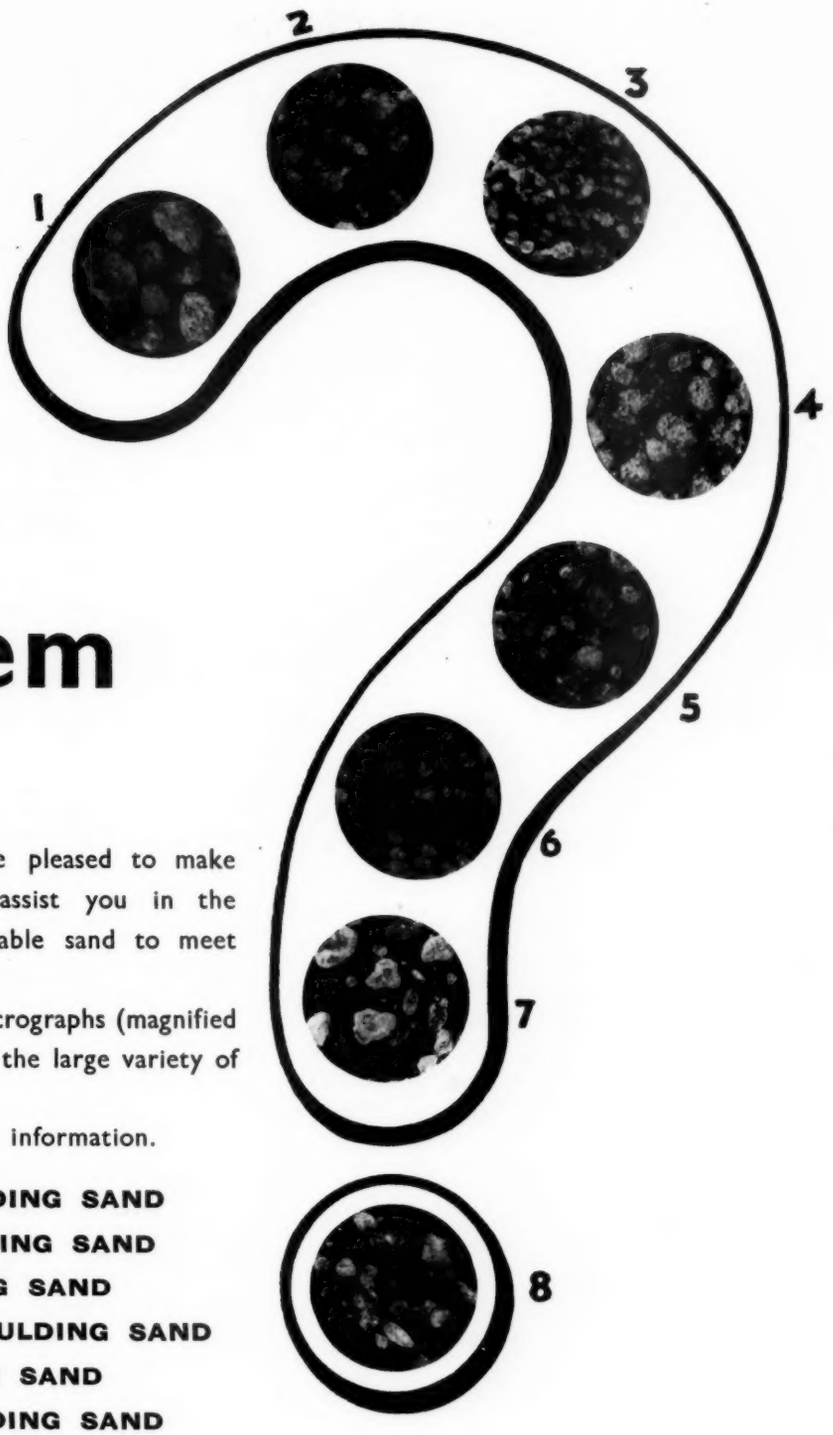

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Raw Material Markets

The outlook in the iron and steel industries now appears to be brighter. Although business is still confined to small tonnages for early delivery, it is fairly certain that many consumers are short of material and will have to buy on a substantial scale after the turn of the year, whatever decision may be taken with regard to prices. Contracts are expiring, but in most instances renewal is being delayed.

Pig-Iron

MIDDLESBROUGH.—There has been a further expansion in delivery specifications during the past week, and it is obvious that consumers' stocks are becoming quite low. In many cases, users have still to take up large tonnages under existing contracts before they will have to re-enter the market, but it is assumed that there is little left of the large quantities of iron which were imported at the beginning of the year. Where contracts have already expired, most consumers are limiting their purchases to small orders for prompt delivery. Until next year's prices are announced, these conditions are likely to continue. For delivery to consumers in the Middlesbrough and Falkirk areas, No. 3 Cleveland G.M.B. foundry iron is quoted at 109s. per ton and 112s. on Clydeside.

Local producers of hematite are still in possession of large stocks and consumers are calling for deliveries at a slow rate. New business is almost negligible. There had been something of a revival in the export section, but, as yet, trade is restricted to meagre tonnages. Prices for home business are fixed for delivery up to the end of the year at 132s. 6d. on the North-East Coast, 138s. in Sheffield, and 143s. 6d. in the Midlands.

LANCASHIRE.—Consumers of pig-iron in this area are limiting their purchases to small tonnages, and most users have still contract deliveries to take up. Activity at many of the users' plants is restricted to about 75 per cent. of normal capacity; this is especially the case with regard to several of the jobbing and speciality foundries. Offers of Staffordshire and Derbyshire brands of No. 3 foundry iron are on the basis of 114s. per ton, with Northamptonshire No. 3 at 112s. 6d. and Derbyshire forge iron at from 111s. to 113s., according to the class of consumer. The hematite market is quiet, and consumers are generally well booked under contract and are not accepting deliveries very regularly. For delivery equal to Manchester. West Coast material is offered at 141s., with East Coast hematite at 140s. 6d.

MIDLANDS.—The outlook in this area is not particularly encouraging from the producers' point of view, at any rate, as consumers are not showing much interest in new business and many of them have contracts which will ensure their being well covered for some months to come. Also, some users, notably the light-castings makers, are not well situated for work and are not likely to take up further tonnages until there is an expansion in trade. In their case this is not expected to arise until after the winter. A few consumers have come to the end of their stocks, and are buying on a small scale, but forward trade is not being entered into. If, as expected, prices are reduced at the end of the year, business is certain to become more active, but producers will be able for some time to supply from stock. Heavy engineers and motor-car manufacturers are calling for quite substantial supplies of low-phosphorus iron and trade in this grade is in good volume. The hematite market is very quiet. New business is almost negligible, while users are not taking up supplies under contract. It is expected that there will be an improvement in this section during the winter months.

SCOTLAND.—Although the pig-iron market in this area continues to be quiet, two blast furnaces which had been idle for several weeks have again been put into production on foundry iron. No. 1 foundry iron is quoted at 120s. 6d. and No. 3 at 2s. 6d. per ton less, f.o.t. furnaces. Many consumers are still working short time and especially is this the case among the light-castings foundries. Local steelworks are quite well employed, but they have large supplies of iron on hand and it will be some time before there is any new business in this section. Hematite mixed numbers are quoted at 133s., Scottish basic at 107s. 6d., and English and Indian basic 100s., all less 5s. per ton rebate.

Coke

There has recently been some expansion of business in the foundry-coke market, and there is now little likelihood of any early reduction in prices. Consumers, as a rule, are not willing to buy far forward, but some have covered their requirements up to the end of the year. For delivery to Birmingham and Black Country stations, best Durham coke is quoted at 50s. 6d., with Welsh descriptions at from this figure upwards.

Steel

A rather brighter tone has been noticeable in the steel market during the past week. This has been due principally to some increase in inquiry which has followed the close of the holiday season and to some expansion in buying. Consumers, however, are disinclined to commit themselves forward, and most of the transactions entered into have been for comparatively small parcels for near delivery. In the semi-finished steel department of the market, similar conditions prevail, but the imports have been on a restricted scale, and the stocks in the hands of consumers, which had grown to large proportions, have been materially reduced. The demand for finished steel is irregular and is not sufficient to enable the producing works to operate on full time. Business in the lighter branches of the industry has shown a slight improvement of late, but there is still a considerable amount of idle plant. Export business shows few signs of expansion.

Scrap

Meetings have recently been held between the National Federation of Scrap Iron and Steel Merchants and the British Iron and Steel Federation with regard to the agreed prices of steelworks' scrap after the end of the current month, but, so far, no announcement has been made. When future prices are made known it is expected that there will be more business transacted, but at present the market is very quiet. Trade in iron scrap, also, is restricted to small parcels for prompt delivery.

Metals

The anxiety which prevailed in the commercial world prior to Herr Hitler's speech at Nuremberg still remains, and has affected metals no less than other markets. Business in all sections has again been quiet and is expected to remain so until the political outlook changes for the better.

Copper.—Consumers have continued to buy sufficient metal to cover their immediate requirements and long-term contracts are not being entered into. It is generally felt that there will be a return to more active conditions as soon as the international situation becomes more favourable, as several consumers in this country are now in the position to make purchases on a substantial scale. Orders from Japan continue to come forward steadily, and this country has bought heavy tonnages during recent months. There has been no improvement in the United States market: it is reported that domestic sales during August totalled only about 20,000 short tons. However, industrial activity on the other side of the Atlantic appears to be reviving, and the outlook is not unsatisfactory.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £41 3s. 9d. to £41 5s.; Friday, £41 to £41 2s. 6d.; Monday, £41 7s. 6d. to £41 10s.; Tuesday, £41 7s. 6d. to £41 8s. 9d.; Wednesday, £41 8s. 9d. to £41 10s.

Three Months.—Thursday, £41 8s. 9d. to £41 10s.; Friday, £41 6s. 3d. to £41 7s. 6d.; Monday, £41 11s. 3d. to £41 13s. 9d.; Tuesday, £41 12s. 6d. to £41 13s. 9d.; Wednesday, £41 13s. 9d. to £41 15s.

Tin.—Dull conditions have prevailed in this market, and the outlook is not very inspiring at present. Consumers, somewhat naturally, are not inclined to place large orders while the political tension exists. Before there is a return to substantial business there are quite heavy stocks to be absorbed. A meeting of the International Tin Committee was held at The Hague yesterday (Wednesday). No change in the quota for the fourth quarter was made. In the United States, tinplate mills are still operating at a low level, and the latest returns from this industry estimate that the mills were working at around 30 per cent. of normal capacity.

Official quotations were as follow :—

Cash.—Thursday, £191 17s. 6d. to £192; Friday, £191 10s. to £192; Monday, £191 15s. to £192 5s.; Tuesday, £192 5s. to £192 10s.; Wednesday, £192 10s. to £192 15s.

Three Months.—Thursday, £192 15s. to £193; Friday, £192 10s. to £192 15s.; Monday, £192 10s. to £193; Tuesday, £193 5s. to £193 10s.; Wednesday, £193 5s. to £193 10s.

Spelter.—It is believed that there will shortly be renewed attempts to form an international zinc cartel. No doubt the formation of a similar organisation among producers of lead has been responsible for the decision to make another effort in zinc. However, there have been so many attempts in the past which have fallen through that not much hope is held for the success of latest moves. The undertone of the market is firm, and consumption has been well maintained, but, generally, dull conditions prevail.

Daily market prices :—

Ordinary.—Thursday, £13 6s. 3d.; Friday, £13 11s. 3d.; Monday, £13 18s. 9d.; Tuesday, £13 18s. 9d.; Wednesday, £14 2s. 6d.

Lead.—The formation of a Lead Producers' Association, referred to in last week's issue, has considerably strengthened this market. It is believed that it is the intention of the Association to cut output by about 10 per cent. There has been a better demand during the past week and the undertone of the market has improved.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15; Friday, £14 18s. 9d.; Monday, £15 1s. 3d.; Tuesday, £15 7s. 6d.; Wednesday, £15 10s.

Scrap.—There has been little, or no, improvement in this market recently and business continues to be confined to small tonnages. A change for the better is expected during the autumn months. With the exception of aluminium, prices of which are unchanged, there has been an upward movement in quotations, in accordance with price movements for the virgin metals.

Approximate selling prices for old metal:—New aluminium cuttings, £67; rolled, £52; cast, £28; foil, £88 to £90. Copper, £37 to £41; braziery, £33. Brass (clean), £22 to £25. Zinc, £9. Lead, £14. Gunmetal, £39.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

487,841. SEABROOK, H. (Weichkernstahlwerk Ges.). Case-hardening of iron or steel.

487,939. HARDY METALLURGICAL COMPANY. Manufacture of alloys.

488,969. HERAEUS GFS., W. C. Wall construction for enclosures and chambers exposed internally to danger of explosion.

British Industries Fair

Telling figures of the growth of the British Industries Fair since 1915, the year of the Fair's inception, are contained in an attractive illustrated booklet issued by the Department of Overseas Trade. How firmly this annual Fair (which in 1939 will be held in London and Birmingham from February 20 to March 3) has established itself in the eyes of the leading overseas and home buyers can best be judged by the attendance figures. In 1915, there was an attendance of 33,676; this year the attendance had grown to 380,031. Manufacturers themselves have increasingly realised the pulling power of the Fair. There were 591 exhibitors at the Fair in 1915; in 1938, there were 2,432. The exhibiting area has grown from 88,714 sq. ft. to 856,396 sq. ft. Officers of the Commercial, Diplomatic and Consular Services, and H.M. Trade Commissioners and the Imperial Trade Correspondents throughout the world keep close touch with overseas buyers. A vital link in this world chain is the fact that the catalogue, with its classified index in nine languages, reaches prospective buyers in many countries weeks before the opening of the Fair—in good time for them to make their plans—and is used throughout the year as a standard reference book. This widespread organisation is at the service of the "small" man and "big business" alike, and the charge for floor space in all sections of the Fair is 3s. 6d. per sq. ft.